GEO
S
599
.03S2A4

LIBRARY
OHIO STATE UNIVERSITY

U. S. DEPARTMENT OF AGRICULTURE,

BUREAU OF SOILS—MILTON WHITNEY, Chief.

IN COOPERATION WITH THE OHIO AGRICULTURAL EXPERIMENT STATION,
CHARLES E. THORNE, DIRECTOR; E. R. ALLEN,
IN CHARGE SOIL SURVEY.

SOIL SURVEY OF SANDUSKY COUNTY, OHIO.

LIBRARY
OHIO STATE
UNIVERSITY

BY

E. R. ALLEN, IN CHARGE, GUY CONREY, W. C. BOARDMAN, OLIVER P. GOSSARD, AND G. K. SIVASLIAN, OF THE OHIO AGRICULTURAL EXPERIMENT STATION, AND CHARLES N. MOONEY, OF THE U. S. DEPARTMENT OF AGRICULTURE.

W E. McLENDON, INSPECTOR, NORTHERN DIVISION.

[Advance Sheets—Field Operations of the Bureau of Soils, 1917.]

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1920.

BUREAU OF SOILS.

MILTON WHITNEY, *Chief of Bureau.*
ALBERT G. RICE, *Chief Clerk.*

SOIL SURVEY.

CURTIS F. MARBUT, *In Charge.*
G. W. BAUMANN, *Executive Assistant.*

COMMITTEE ON THE CORRELATION AND CLASSIFICATION OF SOILS.

CURTIS F. MARBUT, *Chairman.*
HUGH H. BENNETT, Inspector, Southern Division.
W. EDWARD HEARN, Inspector, Southern Division.
THOMAS D. RICE, Inspector, Northern Division.
W. E. MCLENDON, Inspector, Northern Division.
MACY H. LAPHAM, Inspector, Western Division.
M. W. PATTERSON, *Secretary.*

U. S. DEPARTMENT OF AGRICULTURE,

BUREAU OF SOILS—MILTON WHITNEY, Chief.

IN COOPERATION WITH THE OHIO AGRICULTURAL EXPERIMENT STATION,
CHARLES E. THORNE, DIRECTOR; E. R. ALLEN,
IN CHARGE SOIL SURVEY.

SOIL SURVEY OF SANDUSKY COUNTY, OHIO.

BY

E. R. ALLEN, IN CHARGE, GUY CONREY, W. C. BOARDMAN, OLIVER P. GOSSARD, AND G. K. SIVASLIAN, OF THE OHIO AGRICULTURAL EXPERIMENT STATION, AND CHARLES N. MOONEY, OF THE U. S. DEPARTMENT OF AGRICULTURE.

W. E. McLENDON, INSPECTOR, NORTHERN DIVISION.

[Advance Sheets—Field Operations of the Bureau of Soils, 1917.]

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1920.

S 599
O3 S2 A4

LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Bureau of Soils,
Washington, D. C., October 28, 1919.

Sir: In the extension of the soil survey in the State of Ohio during the field season of 1917 a survey was undertaken in Sandusky County. This work was done in cooperation with the Ohio Agricultural Experiment Station.

I have the honor to transmit herewith the manuscript report and map covering this work and to request their publication as advance sheets of field operations of the Bureau of Soils for 1917, as authorized by law.

Respectfully,

Milton Whitney,
Chief of Bureau.

Hon. D. F. Houston,
Secretary of Agriculture.

CONTENTS.

Page.

Soil Survey of Sandusky County, Ohio. By E. R. Allen, In Charge, Guy Conrey, W. C. Boardman, Oliver P. Gossard, and G. K. Sivaslian, of the Ohio Agricultural Experiment Station, and Charles N. Mooney, of the U. S. Department of Agriculture 5
Description of the area 5
Climate 8
Agriculture 9
Soils 13
Miami fine sandy loam 18
Miami loam 20
Miami clay loam 21
Miami clay 23
Crosby silty clay loam 24
Milton silt loam 25
Randolph stony loam 26
Randolph loam 27
Brookston loam 27
Brookston silty clay loam 29
Brookston clay loam 29
Brookston clay 31
Millsdale stony clay loam 34
Newton sandy loam 34
Newton fine sandy loam 35
Newton very fine sandy loam 37
Newton loam 38
Newton silt loam 40
Newton clay loam 41
Newton silty clay 42
Lucas gravelly fine sandy loam 44
Lucas fine sand 46
Lucas very fine sandy loam 46
Lucas silt loam 48
Lucas silty clay loam 49
Warners loam 51
Dunkirk fine sand 52
Belmore fine sand 55
Belmore loam 56
Fox silt loam 58
Waukesha very fine sandy loam 58
Genesee clay loam 59
Muck 59
Marsh 61
Summary 62

ORTON LIB KM

ILLUSTRATIONS.

FIGURE.

Page.

Fig. 1. Sketch map showing location of the Sandusky County area, Ohio-- 5

MAP.

Soil map, Sandusky County sheet, Ohio.

SOIL SURVEY OF SANDUSKY COUNTY, OHIO.

By E. R. ALLEN, In Charge, GUY CONREY, W. C. BOARDMAN, OLIVER P. GOSSARD, and G. K. SIVASLIAN, of the Ohio Agricultural Experiment Station, and CHARLES N. MOONEY, of the U. S. Department of Agriculture.—Area Inspected by W. E. McLENDON.

DESCRIPTION OF THE AREA.

Sandusky County is situated in the northern part of Ohio. Its northeastern corner touches Sandusky Bay, which forms part of Lake Erie.

With the exception of a small area in the southeastern part, between Bellevue and Colby, the county lies within the lake plain of ancient Lake Maumee. This plain is crossed in the southeastern corner of the county by three narrow, nearly parallel ridges, representing shore deposits laid down at successive stages of the receding glacial lakes, designated by geologists as Lakes Maumee, Whittlesey, and Warren.

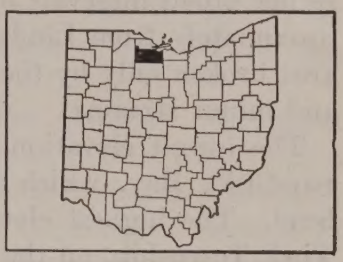

FIG. 1.—Sketch map showing location of the Sandusky County area, Ohio.

The general slope is to the north and northeast. The slope in the western part of the county is very gentle, averaging 10 feet or less to the mile, while the general fall across the eastern part is nearly twice as great, amounting to 220 feet in 12 miles.

While the area included within the old lake plain is in general level and often almost floorlike, there are some undulations and ridges rising 10 to 20 feet above the surrounding plain, and the surface in the western part of the county is relieved by broad, low hills caused by protrusions of the underlying rocks. Some dissection of the plain has taken place along the drainage ways, but for the most part erosion has been slight. The streams flow only 10 to 30 feet below the general level of the plain. The short slopes bordering them, however, are quite steep. Narrow strips of bottom land occur along the larger streams and a few small terraces are found along the Sandusky and Portage Rivers.

The gravel and sand-beach ridges traversing the southeastern corner of the county, approximately from Greenspring to Townsend,

are 150 to 200 yards wide and rise 20 to 30 feet above the adjacent lake plain. Associated with them are rounded sand dunes, frequently rising 30 feet or more above the general level. These dunes are most extensive along the outermost, or Maumee Beach, which is the oldest and represents a larger accumulation of sand and gravel.

The southeastern section of the county consists of level to gently rolling upland, containing numerous small depressions or sinks. Part of this region, just south and southwest of Bellevue, is morainic in topography and hummocky. The extreme southeastern corner consists of rolling glaciated uplands made up of low, broad swells and rather sharply undulating areas. Southeast and east of a line drawn from Rollersville through Gibsonburg is a slightly undulating region whose higher elevations consist of rock hills and sand ridges, alternating with a succession of low, narrow beach lines and ridges rising only a few feet above the surrounding country. Northwest of Gibsonburg the topography is mainly a level plain interrupted at rather broad intervals by rock hills. North of a line extending approximately from Lindsey to Fremont and Whitmore is a large flat area broken only by the recent dissection along the Sandusky River and minor streams.

The lowest elevation in the county is in the marshes bordering Sandusky Bay, which lie somewhat less than 580 feet above sea level. The highest elevation, 800 feet, is reached in two places in York Township, on the ridge crest of the south beach. The difference in elevation, 220 feet, takes place in 12 miles.

The drainage of the greater part of Sandusky County is into the Sandusky River, which crosses the central part of the county from south to north. The next largest stream is the Portage River, which crosses the northwestern corner in a northeasterly direction. There is a conspicuously small development of tributaries, and the greater part of the county is poorly drained. Extensive ditches have had to be dug and tile drains installed before large areas could be reclaimed for agricutural purposes. A system of natural underground drainage is developed in the southeastern corner of the county outside the old lake plain.

As Lake Erie is 573 feet above sea level and the general level of the old lake plain is only 580 to 700 feet, the currents of the streams move slowly. For a distance of about 10 miles from Lake Erie they are very sluggish and occupy channels little below the general level, with no lateral dissection. For another 5 to 7 miles the streams flow gently, but have fairly well-developed valleys lying 30 to 40 feet below the general level and bordered by steep slopes, which are associated with a moderate amount of lateral dissection. Beyond this the streams flow in narrow valleys only 10 to 20 feet deep and are bordered by very narrow flood plains and very steep valley walls

with almost no lateral dissection. Between these last two segments of the stream courses there is usually a section where the streams are swifter than elsewhere in the county.

These conditions are most distinctly illustrated in the case of the Sandusky River. From Lake Erie to a point about three-fourths of a mile east of Ballville this stream is slow moving and may be considered as at base level. From Lake Erie to the mouth of Muskellunge Creek practically no valley has been carved, while above this there is a quite distinct valley with a flood plain and terraces. These differences are, of course, due to differences in the general level of the surrounding upland, the upper or higher one being the more deeply dissected. From a point three-quarters of a mile east of Ballville Bridge to a point about 1 mile west, the fall is sufficient to produce slight rapids, which mark the upper limit of the portion at base level. From the rapids to the county line the stream flows more slowly, though more rapidly than below Ballville. The profile of the river thus shows three main portions—the lower, the rapid, and the upper—with an approximate fall of 6 inches, 17 feet, and 5 feet per mile, respectively.

Similar conditions exist along the smaller streams. The most pronounced valleys along Muddy Creek extend from a point 2 or 3 miles south of Hessville to about the same distance beyond Lindsey; on Muskellunge Creek from the vicinity of the common corners of Washington and Ballville Townships to its junction with the Sandusky River; and along Green Creek from a point northwest of Erlin to a point 2 or 3 miles north of Greenspring. Portage River and Sugar and Toussaint Creeks, in the northwestern part of the county, are sluggish streams flowing approximately at base level in shallow, narrow valleys along which there is practically no lateral dissection. The general level of the plain here, about 25 miles from Lake Erie, is 620 to 640 feet, and the average fall of the streams is less than 2 feet per mile.

Considerable water power is developed at the rapids of the Sandusky River at Ballville. Two hydroelectric plants generate electricity which is used by the city of Fremont and by trolley lines. High-tension circuits are being installed for distribution of power to other cities.

Sandusky County was formed from Indian territory in 1820. The early settlers were largely from New England, but many came from Pennsylvania and New York. The population in 1830 numbered 2,851, and it has steadily increased, amounting in 1910 to 35,171. Deducting from the population classed as rural by the census the towns of Gibsonburg, Woodville, Lindsey, Helena, Greenspring, and Bellevue, the strictly rural or farming population amounted to 14,746, or 35.7 persons per square mile. Of the total number of in-

habitants in 1910, 8.4 per cent were foreign born and 23.7 per cent were of foreign or mixed parentage.

Fremont, formerly Lower Sandusky, is the county seat and largest town, with a population of 9,939 in 1910. Clyde is the next largest place, with 2,813 inhabitants. Gibsonburg, Woodville, Lindsey, and Helena are smaller towns. Bellevue, with a population of 5,209, is mainly in Huron County, but a part of it lies in this county and the census of 1910 credits 1,907 of the inhabitants to Sandusky County. Greenspring, a village of 833 persons, in Seneca County, also extends into Sandusky County.[1]

Several railroads afford adequate shipping facilities for all sections of the county, and numerous large centers of population are within easy reach. The county is fairly well supplied with good roads. Main roads of concrete, brick, or macadam connect all the towns and villages. Rural mail routes reach all parts of the county. The telephone also is in common use, and most of the farm homes are supplied with this convenience.

Fremont is the largest local market for farm products. Sandusky, Norwalk, Tiffin, Port Clinton, Toledo, Cleveland, and Detroit also afford ready markets for all classes of produce.

CLIMATE.

Sandusky County has a climate characterized by cold winters and warm summers, but the extremes of temperature are moderated by the proximity of Lake Erie. Owing to the influence of the lake breezes, which retard warm weather in the spring until there is little danger of frost and prevent the occurrence of early fall frosts, the climate is well suited to the production of fruit and truck crops.

The rainfall is ample and well distributed throughout the year. The mean annual precipitation amounts to 38.95 inches. The rainfall is slightly heavier during the growing season and lightest in the fall. In the driest year on record the rainfall amounted to 31.56 inches and was ample for all crops, while in the wettest year on record it was only 10 inches above normal.

The mean annual temperature is 50.6° F. The winter mean is 28.1° and the summer mean 71.1°. At Tiffin, 10 miles south of the county line, the lowest temperature on record is –17°, recorded in February, but –16° has been recorded in January and a freezing temperature has been reached in every month except June, July, August, and September. The highest temperature recorded at Tiffin is 98°, in July.

[1] Since this report was written the preliminary announcement of the population of Sandusky County and its civil divisions in 1920 has been issued by the Bureau of the Census, as follows: Sandusky County, 37,109; urban, 17,776; rural, 19,333; Freemont, 12,468; Bellevue, total, 5,776; portion lying in Sandusky County, 2,209; Clyde, 3,099; Gibsonburg, 1,737; Woodville, 910; Lindsay, 456; Helena, 209; Greenspring, total 830; portion lying in Sandusky County, 437.

There is an active growing season of 172 days, the average date of the last killing frost in the spring being April 28 and that of the first in the fall October 16. Killing frost has been recorded as late in the spring as May 15, and as early in the fall as September 23.

The table below, compiled from the records of the Weather Bureau, gives the principal climatic data as recorded by the Weather Bureau station at Fremont:

Normal monthly, seasonal, and annual temperature and precipitation at Fremont.

Month.	Temperature.	Precipitation.		
	Mean.	Mean.	Total amount for the driest year (1908).	Total amount of the wettest year (1913).
	°F.	*Inches.*	*Inches.*	*Inches.*
December	29.2	2.66	2.02	1.14
January	29.0	2.84	1.38	6.62
February	26.2	2.57	4.12	2.12
Winter	28.1	8.07	7.52	9.88
March	40.6	3.18	3.92	8.67
April	48.5	3.54	3.43	3.89
May	60.6	3.97	2.90	6.40
Spring	49.9	10.69	10.25	18.96
June	68.2	4.43	1.75	3.72
July	73.9	4.42	4.79	4.79
August	71.3	3.66	4.80	2.85
Summer	71.1	12.51	11.34	11.36
September	65.9	2.81	.56	1.61
October	52.9	2.82	1.11	3.92
November	41.0	2.05	.78	3.05
Fall	53.3	7.68	2.45	8.58
Year	50.6	38.95	31.56	48.78

AGRICULTURE.

Sandusky County was well advanced agriculturally before the Civil War. Among the farm products shipped out of the county for the year 1846[1] were included 90,000 bushels of wheat, 560 barrels of pork, 1,010 barrels of flour, and 18,400 bushels of corn.

A large part of the area was originally swampy, and one of the principal problems of the early settlers was improvement of the drainage. The natural watercourses were improved and some arti-

[1] Howes Historical Collection, Vol. II, p. 523.

ficial ditches dug as early as 1850. Drainage was accomplished by shallow open ditches and by V-shaped, inverted wooden troughs laid underground. Later tile drains were installed and large drainage ditches cut. At the present time the amount invested in drainage improvements is enormous, and reclamation is still going on. In 1915 there were 24,554 rods of tile drains constructed, as compared with 21,645 rods in 1914.

By 1880 the county was well developed agriculturally, 92.8 per cent of its area being in farms and 72.4 per cent of this being improved land. Since 1880 the percentage of farm land in the county has increased to 93.5 and the percentage of improved land in farms to 83.4. In the following table is shown the value of the crops produced in 1909 as compared with the receipts from live-stock sources.

Value of agricultural products, Sandusky County, 1909.

Crop.	Value.
Grains and hay	$2,564,521
Vegetables	348,341
Fruits and nuts	111,564
All other crops	136,216
	3,160,642
Live stock and products	1,737,385
Total	4,898,027

In the level parts of the county, west, north, and northeast of Fremont, the agriculture consists of grain production and the raising of live stock. Corn is perhaps the most important money crop, but this can hardly be designated as a corn-producing section. In the region extending from the south of Fremont to Greenspring and Clyde and almost to Bellevue, the agriculture is distinctly different. In this section orchard and small fruits, cabbage, and melons are extensively grown. Cherries are produced on a large scale in the region between Clyde and Bellevue, and there are a few commercial peach orchards in the vicinity of Clyde. What might be designated as a third type of agriculture is developed in the southeastern corner of the county on the light-colored soils of the rolling upland just beyond the sandy region. Here wheat and oats are more important crops than corn, and fruit and hay are grown extensively.

Corn was grown on a total of 49,846 acres in 1909, and gave an average yield of 36.2 bushels per acre. Oats were grown on 33,327 acres, and wheat on 30,382 acres. In 1880 wheat was the most extensively grown crop, with corn second and oats third.

Clover and timothy hay are important crops. They are grown in the rotation for feed and for soil improvement rather than as a source of income. In 1915, 312 acres of clover were plowed under for green manure. Some timothy hay is sold and some clover and timothy seed is marketed. In 1899, 1,232 tons of clover hay were produced and 23,955 tons of other grasses; in 1909 the production amounted to 5,976 tons of clover, 15,116 tons of timothy, and 18,794 tons of timothy and clover mixed. The average yield of clover was 1.25 tons per acre, of timothy 1.28 tons, and of clover and timothy mixed 1.22 tons.

Alfalfa is grown to a small extent and is gradually increasing in acreage. The production has risen from 28 and 691 tons in 1899 and 1909, respectively, to 1,999 tons in 1915.

Irish potatoes are grown for home use and to some extent for market. In 1909, 353,040 bushels were obtained from 3,586 acres. In 1915, according to the assessor's report, 149,038 bushels were produced from 2,679 acres.

The census reports the value of all vegetables produced in 1909 as $348,341, and the value of the fruit produced as $111,564. In 1909 there were 82,455 apple trees, 17,018 peach trees, 24,835 grapevines, and 174 acres of small fruits. The amount of fruit produced was considerably less than in 1899, but the value of the production was greater.

Crops produced on a small scale for home use and for the local markets include peas, beans, tomatoes, and sweet potatoes.

According to the census of 1910, 8.4 per cent of the value of the average farm, including land, is represented by live stock. The assessor's report for 1915 shows 7,486 milk cows, 5,648 other cattle, 9,908 horses, 22,079 hogs, and 8,500 sheep on farms. In each case the number is considerably lower than in 1909. The census reports the sale or slaughter in 1909 of 4,160 calves, 7,092 other cattle, 1,189 horses, 36,631 hogs, and 9,140 sheep or goats. The total income from this source was $1,098,570. In addition, there were $259,890 worth of dairy products produced, $342,882 worth of poultry and eggs, and $36,043 worth of wool.

Hog raising is especially important in connection with corn growing in the level areas of black soil. The feeding of beef cattle is a fairly well developed industry. On many farms in the western part of the county practically all the products of the farm, with the exception of wheat, are fed to live stock. Sheep raising is largely confined to a number of rocky areas in the western part of the county which have little value for any other use. The live stock kept in Sandusky County is of fair grade, although there are no large pure-bred herds. The horses, especially in the western part of the county, show unusual quality.

Sandusky County presents a very wide range of soils, but the study of their individual adaptation to crops has received little attention. The light-colored sandy soils of the Greenspring and Clyde districts are recognized as well adapted to orcharding and the growing of small fruits and truck crops. The dark-colored sands and sandy loams are recognized as being the best soils for cabbage growing, and this industry is largely developed on such soils. Both the light and dark sandy soils are recognized as well suited to potatoes, but the light-colored types produce the better quality. The light-colored beach soils also are regarded as especially suited to potatoes. The reddish-brown soil over limestone, classed as the Milton silt loam, and the upland glacial-drift soils, classed as Miami loam and fine sandy loam, are recognized as good wheat soils. The dark-colored, friable to moderately heavy soils of the Newton and Brookston series are recognized as excellently adapted to corn. The very heavy types of these series also are considered good corn soils, but it is recognized that they can not be devoted exclusively to this crop and that they require special care in handling.

Elaborate drainage systems, consisting of large open ditches and intricate systems of tile, have been installed on the heavy, poorly drained soils. Tractors are used to plow these soils on many farms. On the sandy soils tillage operations are very easily accomplished and the lighter agricultural implements suffice as a rule. Some rolling, planking, dragging, and compacting is done on the light-colored sands in the southeastern part of the county. Where cabbage and potatoes are grown to a considerable extent on these light sandy soils, machines are used for setting the cabbage plants and for planting and digging the potato crop.

Some fall plowing is done, but spring plowing is the general rule. Much of the corn crop is cut in the fall and shocked, but some of the fields are hogged down. Hay is generally stored in barns or sheds. Oats and wheat are frequently stored in barns in the sheaf until they can be thrashed.

The farm equipment in the better districts of the county includes large barns and modern machinery. The census for 1909 reports the average value of all property per farm as $9,543, of which 2.9 per cent covers investment in implements.

More attention is given to crop rotation in Sandusky County than in most sections of this country. Some of the best farmers have followed fairly systematic rotations for 20 years. The most common rotation consists of corn, oats, wheat, and clover, but there is a tendency to grow corn more often and clover less often than once in four years. Furthermore, the clover is frequently followed by timothy.

Fertilizers are being used to an increased extent. They are already in fairly general use on wheat. Farmers report that as the soils

decline in productiveness it is necessary to use fertilizers on wheat earlier than on corn, in order to maintain satisfactory yields. The expenditure for fertilizers increased from $4,003 in 1879 to $12,140 in 1899 and $44,960 in 1909. In the latter year 44.5 per cent of all the farmers used fertilizers, at an average expense of $34. The assessor's report shows a total expenditure of $50,161 in 1915. The usual fertilizer is a mixed preparation containing phosphoric acid as the principal constituent. The best farmers find that for most of the soils straight acid goods, i. e., acid phosphate, produce the best returns on the investment for grain production.

The farm labor in this county is entirely white and largely American born. In 1910, 1,585 of the 2,945 farms in the county reported the employing of labor, the average expenditure per farm being $206.

The farms range in size from 40 to 200 acres. The greater number are between 80 and 120 acres. The average size in 1910 was 83.9 acres. The percentage of farms operated by tenants is slowly increasing. In 1880, 24.2 per cent of the farms were operated by tenants, as compared with 35.7 per cent in 1910.

The average assessed value of farm land in 1900 was $53.78 an acre, and in 1910, $77.54 an acre. Values in the black-land region range from $90 to $200 an acre, while sandy and rocky areas are much lower priced.

SOILS.

Sandusky County lies within the glacial region of the United States and the soils are included in two soil provinces, the Glacial and Loessial and the Glacial Lake and River Terrace. Nearly all the soils have been formed from material deposited in or inundated for a long period by ancient Lake Maumee, which covered all this area except the southeastern corner.

The soil-forming material is quite complex. As in all glaciated regions, the influence of the underlying rocks is indirect, yet differences due to the rocks themselves have not been obliterated entirely. The underlying rocks consist mainly of alternating levels of the Niagara and Waterlime formations passing from north to south, but there is an area of perhaps 30 square miles in the southeastern corner of the county underlain by the Corniferous formation. All these are very nearly pure dolomites, and there seems to be little difference in their soil-forming properties. The Corniferous limestone is capped by the Olentangy and Ohio shales, but little of this shaly material remains within this area at the present time. It is probable that at an earlier period these Devonian shales existed over the present area and for some miles to the north and northeast. East of the county the underlying rocks are the Waverly and Maxville shales and sandstones of the Mississippian or Lower Carboniferous. The

continental ice sheet, which passed over these rocks, left a mantle of débris ranging from 1 foot or less to over 50 feet in thickness.

The southeastern corner of the county, which is underlain by Corniferous limestone, is slightly higher lying than the remainder of the area. It represents the beginning of the escarpment which marks the transition from the Devonian and Silurian limestone rocks of western Ohio to the Mississippian and Pennsylvanian sandstones and shales of eastern Ohio. As the movement of the ice sheet was approximately parallel to the foot of this escarpment more sandstone was incorporated into the drift in this region, and the influence of this is apparent in the soils at the present time. Two main types of drift are consequently present in the area, one very calcareous and the other but slightly so.

At the close of the glacial period Lake Maumee occupied a large area in northwestern Ohio, northeastern Indiana, and southeastern Michigan, and drained to the west into the Wabash River through a channel near the point where Fort Wayne, Ind., now stands. Later, owing to changes in elevation, a lower outlet was formed near Imlay, Mich., which caused the lake to recede. In its smaller extent the lake is known as Lake Whittlesey, and similarly a subsequent lake was formed, known as Lake Warren. The higher lying southeastern corner of the county formed a natural shore for these lakes, and all three of the beaches crossed it in a northeast-southwest direction, their position being marked at the present time by deposits of sand and gravel. The outermost beach, that of Lake Maumee, was formed by the lake at its greatest extent and is the most prominent. Large areas of sandhills and dunes are associated with this beach.

According to Leverett, the beach of Lake Warren crossed the southwestern corner of what is now Sandusky County. Instead of occupying one position for a considerable period of time Lake Warren apparently receded gradually northeastward, and as the slope is very slight minor changes in the outlet produced considerable differences in the shore line of the shallow lake. At any rate, south and southeast of a line passing from Gibsonburg to Rollersville and west to the county line there is a region covered with sandy deposits characteristic of shallow lakes and irregularly interspersed with beach deposits. The latter, though distinct, are less prominent than those in the southeastern corner of the county. The sandy constituents of this material have drifted into small dunes in places. Owing to these complex conditions and to the fact that the till has not been completely covered, and that the underlying rocks protrude in places, the soil distribution is extremely complicated.

Over the western part of the county there are a number of knobs of Niagara limestone which were not planed down by the ice sheet and

which protrude through the glacial drift. These areas have undergone little weathering since the close of the glacial period, and at the present time are quite stony. These rock ridges in the beach region possibly formed barriers or helped establish the shore line, as the present beach lines are often found near the rock hills or extend out from them.

While there seems to have been some material deposited in the shallow water of the former lake near the old shore lines, for some distance toward the middle of the lake the material is apparently till. It has a floorlike surface and the soil is very heavy, suggesting a lacustrine origin, but the fact that pebbles and small stones are found throughout the 3-foot section and true till only a short distance below, the resemblance of this material to that in other areas which is undoubtedly till, and the presence of occasional bowlders indicate that this soil is more likely ground-morainic material derived largely from Devonian shale and Niagara limestone. In the innermost lake (Lake Warren) of the old lake basin are found extensive areas of undoubtedly lacustrine soil. This ranges from 3 to 15 feet or more in depth, is free from pebbles, and more or less distinctly stratified.

The upland soil-forming material of Sandusky County is therefore composed of glacial till derived from limestone and shale; of glacial till derived from limestone, sandstone, and shale; of beach deposits; and of lacustrine deposits. The till derived from limestone and shale (with, of course, a slight mixture of igneous and other foreign material from formations more distantly removed) is confined to the lake plain. It is very heavy and was originally highly calcareous, but this property is not now always manifested within the 3-foot section. The till derived from limestone, sandstone, and shale is lighter in texture and was no doubt originally calcareous, but this property is now almost nowhere manifested within the 3-foot section. The gravelly material of the beaches is highly calcareous and this property is possessed to a marked degree by the resulting soils, but the sand of related origin is not calcareous. The alluvial soils are noncalcareous except in a few cases.

In correlating the soils other differences besides origin and nature of the material must be recognized. The light-colored soils are separated from the dark, and are subdivided with respect to differences in color, structure, mottling, and other surface and subsoil properties which have resulted from weathering under different conditions of drainage and which are more or less important agriculturally. Soils of similar origin, with the same range of color in the surface layer and the same color and structure within the subsoil, are classed together as a series. The different series each include

a number of types which differ in texture, i. e., in the relative proportion of coarse and fine particles which form the soil. The soil type is the unit of classification.

Six series are recognized in the soils derived from glaciated limestone, sandstone, and shale. Types with a yellowish-gray surface soil, a somewhat mottled subsurface layer, and a yellow or dull-brown subsoil often overlying highly calcareous, partly weathered till, are classed in the Miami series. Soils with a light-gray surface portion, an ashy-gray subsurface layer, and a plastic, iron-streaked, dingy-gray subsoil are classed in the Crosby series. Areas with yellowish-brown surface soils and brown to reddish-brown, heavy, sticky subsoils, underlain by limestone rock within the 3-foot section, are mapped with the Milton series. Where the surface soil is grayish yellow to dull brown and underlain by a dull-brown subsoil overlying limestone rocks, the soil is correlated in the Randolph series. The Brookston series includes the types with a grayish-black surface soil, a bluish-gray subsurface layer, and a yellowish subsoil. The silty clay loam occurs in small areas, originally ponds, outside the old lake plain, and doubtless owes its silty nature to the blowing and washing in of material from the surrounding higher areas. The other types of this series are confined almost entirely to the old lake plain. The clay has been derived from glacial till unmodified except by the addition of organic matter. The Millsdale series is characterized by dark-gray to black surface soils and gray mottled subsoils resting upon limestone bedrock at a depth of less than 3 feet.

In the soils derived from water-deposited material seven series are recognized. The soils of the old lake plain, with heavy subsoils, are classed in the Newton, Lucas, and Warners series.

The Newton series includes types with a grayish-black surface soil, a bluish-gray subsurface layer, and a yellowish subsoil. They differ from the Brookston soils mainly in structure. Being derived from assorted material, the Newton soils are composed more exclusively of soil particles of only two or three grades than the Brookston soils, resulting in a smoother feel and a peculiar compactness. The Newton soils, while not acid, are not calcareous within the 3-foot section. As a general rule, the heavier types have been derived from the deeper lacustrine deposits well out in the old lake plain, while the lighter have been formed from shallow deposits near the old shore line and exist in small and irregularly distributed patches. This mode of deposition accounts for the fact that the lighter soils do not possess so smooth a feel and contain some pebbles, while the heaviest types are smooth and light in structure and entirely free from pebbles. There is considerable color variation in the subsoils, yellow being the dominant color in the lighter types and bluish-gray in the heavier.

The Lucas series is distinguished by its yellowish-gray surface soil and yellowish-brown, distinctly heavier subsoil. The subsurface layer may or may not be slightly mottled. The lower subsoil of the lighter members usually is not calcareous, but the heavier types have a calcareous lower subsoil.

In some areas the soil consists of a dark-gray marly loam, underlain by a subsoil of whitish marl, marly sand, or marly clay. This is classed in the Warners series.

The water-deposited soils derived from beach deposits or from other associated sandy and gravelly deposits are classed in two series, the Dunkirk and the Belmore. The Dunkirk series includes soils which are yellow throughout the 3-foot section. In this county the material is typically wind blown. The gravelly areas are composed of material evidently deposited in shallow water and little drifted by wind, since pebbles are found throughout the 3-foot section. Where the surface soil is yellowish-brown to brown, with a brown to reddish-brown subsoil overlying highly calcareous gravel, the Belmore series is recognized. The Belmore soils occupy the deeper and more prominent beach deposits.

The water-deposited soils occupying glacial terraces along streams and lying above present-day overflow are classed in two series. The Fox includes the areas with yellowish-brown surface soils and brown subsoils overlying rounded calcareous gravel. The Waukesha includes the types with brownish-black to black surface soils and yellowish-brown subsoils.

The soils occupying the flood plains along streams, consisting of recent alluvium washed from the drainage basin of the watercourses and deposited at times of overflow, are correlated with the Genesee series. They have a grayish surface soil and a dingy-gray to bluish-gray subsoil.

Besides the soils grouped in the 14 series mentioned, certain areas are mapped as miscellaneous soils.

Areas of organic soils are mapped as Muck. Some of these areas consist partly of Peat (fibrous) and partly of Muck (nonfibrous), but as the total area is small and the two types of material are intimately associated they are not mapped separately. Where the areas are underlain by a marly layer they are shown as a marly phase. Soils continually in a marshy condition—i. e., inundated with shallow water and incapable of being drained except by means of dikes and pumping systems—are classed as Marsh.

In the following pages of this report the various soils of Sandusky County are described in detail and their relation to agriculture discussed. Their distribution is shown on the accompanying

map. The table below gives the name and the actual and relative extent of each type:

Areas of different soils.

Soil.	Acres.	Per cent.	Soil.	Acres.	Per cent.
Brookston clay	67,136	25.4	Randolph loam	2,944	1.1
Newton silty clay	37,120	14.0	Lucas gravelly fine sandy loam	2,816	1.0
Dunkirk fine sand	17,024	7.7	Lucas very fine sandy loam	1,280	1.0
Gravelly phase	3,392		Coarse phase	1,344	
Brookston clay loam	17,984	6.8	Warners loam	2,432	.9
Newton fine sandy loam	15,616	5.9	Millsdale stony clay loam	1,792	.7
Miami clay loam	13,312	5.3	Brookston silty clay loam	1,728	.7
Light phase	704		Miami clay	1,472	.6
Randolph stony loam	7,680	2.9	Muck	960	.6
Genesee clay loam	7,616	2.9	Marly phase	512	
Newton clay loam	6,784	2.6	Fox silt loam	1,152	.4
Lucas silt loam	6,720	2.5	Belmore fine sand	1,152	.4
Brookston loam	5,888	2.2	Waukesha very fine sandy loam	1,088	.4
Newton very fine sandy loam	5,760	2.2	Crosby silty clay loam	1,024	.4
Lucas silty clay loam	5,504	2.1	Milton silt loam	960	.4
Newton silt loam	4,480	1.7	Lucas fine sand	960	.4
Marsh	4,416	1.7	Belmore loam	576	.2
Miami loam	4,288	1.6	Newton sandy loam	256	.1
Newton loam	3,392	1.6	Gravel and clay pits and quarries	256	.1
Gravelly-subsoil phase	832				
Miami fine sandy loam	960	1.5	Total	264,320	
Heavy-subsoil phase	3,008				

MIAMI FINE SANDY LOAM.

The Miami fine sandy loam, to a depth of 8 inches, consists of a light yellowish brown, rather compact fine sandy loam. The subsurface material to a depth of 22 to 24 inches is a light-yellow, rather compact fine sandy loam. It gradually becomes slightly heavier and grades into a dull yellowish brown, gritty clay loam at 24 to 28 inches. Below this the material consists of friable, partly weathered till, which is not calcareous to a depth of 3 feet or more.

This soil is confined to a few small areas in the southeastern corner of the county. Its topography is gently rolling to ridge-like, and both surface drainage and internal drainage are quite thorough.

This is a productive type, despite its high content of sand. The sandiness probably is partly counterbalanced by the heavier subsoil and by the fact that the sand is fine. The soil is easily plowed and worked into a desirable seed bed. The farmers plank and roll the soil after it has been plowed. Fertilizers are used to a moderate extent and give good results.

Miami fine sandy loam, heavy-subsoil phase.—The Miami fine sandy loam, heavy-subsoil phase, to a depth of 7 or 8 inches, consists of a yellowish-gray fine sandy loam, underlain by a yellow and gray, rather distinctly mottled, slightly more coherent fine sandy loam. The content of clay increases with depth, and at 18 to 20 inches the subsoil passes into a heavy, compact, yellowish-brown to dull-brown clay, the prominent gray mottlings disappearing entirely. Below 20 inches the sand almost entirely disappears, and at 22 to 24 inches there is abruptly encountered a compact, friable, highly calcareous till. The dense layer overlying the till is spoken of by the farmers as hardpan.

In the areas of the phase in Riley and York Townships the sandy material continues in the subsoil practically to the till, and in some places the till itself is quite sandy. In the western part of the county, however, especially around Woodville, the material in many places is free from fine sand just above the till. In such areas the fine sandy material probably has been deposited over the heavier till and has not weathered directly from the underlying material.

The Miami fine sandy loam, heavy-subsoil phase, has a level to gently undulating surface. It occurs on low ridges and swells, and the surface drainage is fairly good. The internal drainage, however, is rather poor, as is shown by the prominent mottling.

This is an unimportant soil agriculturally. It occupies small strips, and very few large fields are located entirely on it. In some places it is used for general farming, although it is recognized as a rather poor corn soil. It gives fairly good results with wheat and is quite well suited to potatoes, to which it is often planted. The soil is not difficult to handle. Farmers recognize that the natural drainage must be supplemented by underdrainage. The tiles are usually placed 2 rods apart, but in some cases at greater distances. Tillage operations can be carried on with ordinary implements, and the seed bed is quite readily prepared. Fertilizers are used to a limited extent, and good results are reported from their use.

In the improvement of this soil moderate applications of lime would prove beneficial, especially in connection with such crops as clover and alfalfa. Alfalfa can be grown in many places where tile drainage has been provided and where the surface soil has been limed. Wherever possible green manures and organic matter of all kinds should be plowed into this soil.

The following table gives the results of mechanical analyses of samples of the soil, subsoil, and lower subsoil of the typical Miami fine sandy loam, and of the heavy-subsoil phase:

Mechanical analyses of Miami fine sandy loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
Typical:		*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
272273	Soil	0.6	2.5	3.2	32.0	15.8	36.8	8.8
272274	Subsoil	.2	1.8	2.0	34.9	15.0	34.9	10.1
272275	Lower subsoil	.7	3.9	2.6	19.5	12.3	40.2	21.5
Heavy-subsoil phase:								
272270	Soil	2.5	4.6	3.8	45.8	9.9	22.6	10.5
272271	Subsoil	1.8	4.2	2.7	51.2	8.4	18.7	12.8
272272	Lower subsoil	.9	1.5	1.2	12.3	6.4	46.5	31.2

The following sample contained more than one-half of 1 per cent calcium carbonate ($CaCO_3$): No. 272272, 12.65 per cent.

MIAMI LOAM.

The soil of the Miami loam consists of 15 inches of pale-yellow, friable, mealy silt loam. In cultivated fields the surface soil has a light-brown tint, owing to the presence of organic matter. In the virgin areas 2 or 3 inches of dark material is found on the immediate surface, which is underlain by the typical pale-yellow, friable silt loam. Below about 7 inches the soil often shows some variegation, which becomes more distinct and gives rise to gray mottling at 18 inches. From this depth to 24 inches the subsoil is a brown and gray mottled clay loam which contains dark iron streaks. Below 24 to 27 inches the material becomes a friable, yet rather compact, unweathered or slightly weathered till, which is moderately calcareous below 36 inches. The subsoil material overlying the till is quite impervious and heavy.

The Miami loam occurs in the glacial-till region in the extreme southeastern corner of the county. It occupies a few level areas, but most of the type is gently rolling. In places there is a series of morainic knobs and sags. The surface drainage is generally thorough and the internal drainage fair. Some artificial drains have been installed, but artificial drainage is not as necessary as on the dark soils within the lake plains.

The Miami loam is of moderate extent and importance in the county. It is used for the production of corn, wheat, oats, and potatoes. Wheat does fairly well, yielding 15 to 25 bushels per acre. Oats yield 20 to 30 bushels and corn 30 to 40 bushels per acre.

The soil is easily tilled, and the seed bed is quite readily prepared with ordinary spike-tooth harrows. Some fertilizers are used, and the amount is increasing slowly. The particular fertilizer or combination of fertilizers best adapted to this type has not yet been worked out, but the farmers invariably report good results when straight acid phosphate is used.

Farm values on this type range from $70 to $100 an acre. Some areas nearer town are held at slightly higher prices.

The results of mechanical analyses of samples of the soil, subsoil, and lower subsoil of the Miami loam are given in the following table:

Mechanical analyses of Miami loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
272201	Soil	1.3	3.3	3.0	19.0	15.4	45.4	12.5
272202	Subsoil	1.6	4.0	3.3	17.5	13.2	38.1	22.2
272203	Lower subsoil	1.4	3.6	2.8	15.8	15.0	39.0	22.2

MIAMI CLAY LOAM.

The Miami clay loam, to about 8 inches, consists of a gray silt loam or loam which is quite mellow in some places but heavy in others, often grading to a light clay loam. In numerous areas the soil has an appreciable content of sand, and where these areas are of sufficient extent they are indicated on the map as a light phase. In some places where the type occupies flat ridges, stones, pebbles, and bowlders are found on the surface and throughout the 3-foot section. The more conspicuous of these areas are indicated on the map by symbol. The surface material in new areas is tinted with yellow, but in dried and beaten fields it appears light gray to almost white.

The subsurface material consists of a bright yellow and gray mottled, plastic, silty clay loam to clay loam. This is rather friable in the upper part, but it rapidly becomes heavier, and at 15 inches a heavy, compact clay with a peculiar plasticity is encountered. The color to a depth of 20 to 22 inches is a peculiar bright yellow or tan, with a few gray mottlings below 15 inches. Below a depth of 20 inches the material becomes dull brown in color, and is very heavy and tenacious. At 24 inches it gives way rather abruptly to a compact, heavy, highly calcareous till, which is quite crumbly and friable in comparison with the overlying layer. Some fragments of rotten limestone and black shale and some limestone concretions occur in the lower part of the 3-foot section. On the whole the material is highly calcareous, effervescing freely with mineral acids.

There are several areas of silt loam included with this type, but as the silt loam layer is only 10 to 12 inches deep and underlain by a heavy subsoil, and as the total extent of such soil is small, separation did not seem warranted. The largest of these areas lies at Hessville.

The Miami clay loam occurs in the slightly better-drained situations in the lake till region. It is developed almost entirely in small areas

adjacent to streams and on the low ridges and small swells on the lake plains. The topography is undulating to very gently rolling. In some places where the type adjoins the Brookston clay the surface is very nearly level, and in such places the boundary between the two types is quite indistinct. The soil here is also heavier than in the typical areas west and southwest of Woodville.

The natural surface drainage of the Miami clay loam is fair, but the internal drainage is rather poor, owing to the heavy texture and the close, impervious structure of the subsurface and subsoil layers. Artificial drainage is very difficult to accomplish. Farmers report that in order to drain this soil properly the tile should be placed at a depth not greater than 24 inches and at intervals of 15 to 25 feet. The compact subsoil layer is locally termed hardpan by the farmers, who state that tiles placed below this depth do not improve drainage. Even when placed at a depth of 20 to 24 inches the excess water does not move from any considerable distance to the side.

The Miami clay loam is of small extent and it is rather unimportant agriculturally. The type is in a modern state of improvement, but it is recognized as being much lower in productiveness than the darker soils. It is difficult to handle, and owing to the amount of clay in the surface soil it bakes and becomes cloddy if plowed when too wet. The soil is moderately well suited to corn, but is better for shallow-rooted crops, such as wheat and oats. Clover grows moderately well, not luxuriantly as on the darker types. A fair estimate of yields, based on statements of farmers, is as follows: Corn 25 to 40 bushels per acre, wheat 12 to 20 bushels, and oats 30 to 40 bushels.

Plowing is done mostly with two and three horse plows, and heavy harrows and disks are used in preparing the seed bed. Fertilizers are used to some extent on this type and good results have usually followed. Liming has proved beneficial, especially with such crops as clover. Farmers state that wherever the calcareous till from the lower subsoil is spread over the surface, as along tile ditches and near deep postholes, crops do noticeably better.

Land of the Miami clay loam is valued at $75 to $125 an acre.

In improving this type the use of limestone should be encouraged. While red clover will grow without any treatment, the growth is far less luxuriant than on other soils which are in a less acid condition. Liming will incidentally increase the benefit to be derived from the growing of a legume in the rotation. Fertilizers containing acid phosphate as the principal constituent should be used. Tiling is a problem on this type. The tiles must be laid very close together to obtain good results, and this is very expensive. It is an open question whether deep-rooted crops, such as alfalfa and sweet clover, would be profitable. It is also questionable whether deep fall plow-

ing would give good results. Some farmers report that the soil compacts to an excessive degree when plowed in the fall.

Miami clay loam, light phase.—The Miami clay loam, light phase, to 7 or 8 inches, is a yellowish-gray, rather friable loam, containing sufficient clay to be coherent when wet. The subsurface material, to a depth of 12 to 14 inches, is yellow and gray in color and usually slightly heavier, though containing sufficient sand to have a slightly gritty feel. The subsoil is a dull-brown and yellow streaked, compact clay, giving way to friable, crumbly, highly calcareous till at 27 to 28 inches. In short, the lower part of the 3-foot section is very similar to that of the typical Miami loam, while the upper part is distinctly more gritty.

This phase occurs in small areas throughout the better-drained parts of the lake-till region. It is intimately associated with the typical Miami clay loam. It apparently has a slightly higher agricultural value than the typical clay loam, and is easier to work.

In the following table are given the results of mechanical analyses of samples of the soil, subsoil, and lower subsoil of the typical Miami clay loam:

Mechanical analyses of Miami clay loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
272221, 272240a	Soil	0.9	1.9	1.4	8.1	12.6	47.1	27.7
272222, 272241.	Subsoil	1.0	2.8	2.1	10.5	11.0	35.8	36.6
272223, 272242.	Lower subsoil	1.6	3.5	2.3	9.7	9.7	39.9	33.4

The following samples contained more than one-half of 1 per cent calcium carbonate ($CaCO_3$): No. 272222 1.45 per cent; No. 272223, 15.15 per cent; No. 272240a, 0.65 per cent; No. 272242, 17.77 per cent.

MIAMI CLAY.

The Miami clay consists of 7 or 8 inches of grayish-yellow clay or heavy clay loam, underlain by a rather compact, plastic clay which is dull yellowish brown in color, and slightly mottled with gray just below the surface. The subsurface material gives way at 20 to 30 inches to a more friable, crumbly clay, dull brownish yellow in color and containing some grit and pebbles. This lowest layer is calcareous, the calcium carbonate probably representing in part unaltered limestone fragments and in part material leached from upper layers.

The Miami clay is closely associated with the Brookston clay, but it occupies slightly better drained areas near the streams. It occurs for the most part in long, narrow strips, since the dissected areas along the streams are of small extent. The run-off is only fair, and the internal drainage is poor.

The productiveness of this soil is recognized as being quite low and especially subject to seasonal influences. One of the obstacles in the way of improving the soil, besides its poor physical condition, is the difficulty of removing excess water. Tiles are relatively ineffective, as the impervious nature of the subsoil makes the movement of water extremely slow. Farmers on parts of this type state that water frequently stands directly over the tiles. Under such conditions the soil is perhaps better adapted to pasture than to cultivated crops. It is hard to work and becomes cloddy and almost intractable if stirred when wet. It is a "cold-natured" soil, and crops get a late start in the spring.

CROSBY SILTY CLAY LOAM.

The soil of Crosby silty clay loam consists of 6 or 7 inches of gray, floury, smooth silt loam, low in organic matter. In beaten fields the surface is strewn with small iron concretions and the color is almost white. The subsurface material consists of a compact, mealy, yellow silt loam, invariably marked with large ashy-gray mottlings. The texture becomes heavier at about 12 inches, and the mottlings larger and more distinct. Below this the subsoil is a dull grayish yellow, soft, puttylike silty clay loam. At 24 to 26 inches there is reached a more friable yet compact material containing grit and fragments of rock. This material represents the partially weathered glacial material, but is not calcareous, and the unweathered material below 3 feet is only moderately calcareous. In this respect the soil differs strikingly from the Crosby silt loam and silty clay loam of Miami and Marion Counties.

The Crosby silty clay loam occupies scattered areas in the southeastern section of the county. It is intimately associated with the Brookston silty clay loam and the Miami loam, and represents similar soil material weathered under poorly drained conditions. It has naturally a level topography, and is poorly drained. The internal drainage is especially poor, owing to the impervious subsoil, and artificial drainage is not easily established.

This is not an extensive type, and it is not important in the agriculture of the county, although it is all cleared and farmed. The original tree growth consisted of oak, hickory, and beech. General farming is carried on, although the type is recognized as a rather poor corn soil. It perhaps gives best returns with shallow-rooted crops, such as timothy and hay, which do not require large amounts of water during the hot summer months. Corn yields 30 to 35 bushels per acre, wheat 10 to 12 bushels, and oats 25 to 35 bushels. Clover varies widely in yield.

This soil is easily plowed and worked into a good seed bed. Fall plowing is not deemed advisable, as the soil packs too firmly during

the winter, and deep plowing also seems to be of very doubtful value. Fertilizers are in common use, as yields are low without fertilization.

Land values on the Crosby silty clay loam range from $50 to $70 an acre.

In improving the drainage of this type a system of tile drains might not be successful or economical, but much can be accomplished by installing some tile drains and supplementing them with surface ditches. The fertilizers in use should be accompanied by the application of ground limestone and the growing of legumes.

It is probable that the difficulty experienced in growing clover on this type is due in part to the lack of lime, as the general color of the surface soil and the condition of the subsurface layer indicate acidity. Owing to the compact nature of the silty surface soil, crusts are likely to be formed after a rain, preventing the proper germination of the seed. This crust can be easily broken up with a light harrow.

MILTON SILT LOAM.

The Milton silt loam consists of a brown to faintly reddish brown, friable, mellow silt loam, 8 to 10 inches deep, underlain by a slightly brighter colored silt loam which merges at a depth of about 13 inches into a reddish-brown, plastic clay. This sticky, impervious subsoil is one of the striking characteristics of the type. It contains small fragments of resistant pebbles, but practically no other drift material. The material becomes slightly heavier until bedrock is encountered, usually at 18 to 24 inches. No calcareous material is encountered in the 3-foot section, except in the rock débris lying directly on the bedrock. In some places the surface material is distinctly gritty and really a loam in texture.

The Milton silt loam occupies rather small areas in the southeastern part of the county. The soil is evidently derived in part from the underlying rock and in part from thin deposits of till. It is found on the lower, rounded hills which resisted planing down by the ice sheet.

The topography is broadly rolling to almost level, with little relief, but the run-off and underdrainage are excellent, owing partly to the cracks and rifts in the bedrock.

While this type is not extensive or important, the soil is very productive, and it is all cleared and in a high state of improvement. The original tree growth is said to have been composed of sugar maple, oak, and hickory. The Milton silt loam is recognized as a good wheat soil. Clover also grows luxuriantly, and the type is well adapted to a number of other crops, including corn and oats. Wheat yields 25 to 30 and occasionally 35 bushels per acre, corn 40 to 50

bushels, and oats 30 to 40 bushels. This soil seems to be unusually durable, as is evident from the fact that it can be severely cropped for years in a rotation of corn, wheat, and clover with very little decline in yield.

The soil is friable and easily worked. Fertilizers are used to some extent on wheat and corn, although wheat and clover give good yields without fertilization.

Land values on the Milton silt loam range from $150 to $175 an acre.

In improving this type attention should be given to the growing of green-manure crops, such as the legumes, which do so well on this soil. Alfalfa could probably be grown very successfully. This soil in Miami County is recognized as excellent for tobacco. It is also well adapted to potatoes.

RANDOLPH STONY LOAM.

The soil of the Randolph stony loam in most places is only 8 to 12 inches deep. It consists of a dull-brown or dull-yellow, rather heavy loam to light clay loam, often becoming slightly heavier as bedrock is approached. The soil is so stony and contains so much rock outcrop that it has practically no agricultural value. There is only a scant growth of grass, and this is scarcely accessible to live stock.

Included with the Randolph stony loam are some small areas of Milton stony loam and stony clay. The stony loam consists of 7 to 8 inches of brown to slightly reddish brown loam, with a subsurface layer of reddish-brown, slightly more coherent loam which rests on bedrock at 9 to 12 inches. The Milton stony loam occupies the crests of a few of the rock barriers near Fremont and to the west of that place. The surface is thickly strewn with fragments of limestone rock, making cultivation difficult. The soil is moderately productive in spite of its shallowness and stoniness, though it is somewhat droughty for such crops as corn. Fair yields of wheat are obtained. The type supports a good growth of bluegrass.

The Milton stony clay consists of 8 to 10 inches of brown clay loam or clay, underlain by a very plastic, sticky, reddish-brown clay. The bedrock is usually encountered at a depth of 10 to 12 inches. The surface soil and subsoil are so stony that it is often impossible to penetrate it with the soil auger. Bowlders are usually scattered over the surface. The Milton stony clay is found on the crests of some of the rough ridges north and northwest of Bellevue. It has a very low agricultural value, as it can hardly be cultivated. Its chief use is for pasture.

RANDOLPH LOAM.

The surface soil of the Randolph loam consists of a dull yellowish gray, heavy loam to light clay loam, 7 to 8 inches deep. The soil generally contains sufficient sand to be slightly gritty, and there is a rather high content of subangular rock fragments and stone. As a rule these are not abundant enough to interfere seriously with tillage operations, but in a few fields it has been necessary to remove the stones before the land could be farmed to advantage. The material from 7 to 12 or 18 inches is a dull yellowish brown clay loam or clay, slightly mottled in the upper part. Bedrock is usually encountered at a depth of 12 to 18 inches, in which case the heavy clay or clay loam material rests directly upon it. In places, however, bedrock is not encountered above 24 to 30 inches, and here there is usually some friable, highly calcareous till material below the heavy subsoil.

The Randolph loam occurs on the rock ridges and on the gentle slopes of such ridges in the western part of the county. The topography is level to undulating, and the surface drainage is fair, but the internal drainage is rather poor. The nearness of the underlying rock prevents the free movement of water and the proper development of root systems.

This is not an important type agriculturally, although fair crops of corn, wheat, and clover are sometimes produced. There are a few fields of alfalfa on this type. The installation of tile drains is of considerable benefit to this soil, but the expense incurred in digging and blasting is so great that artificial drainage is of doubtful advisability. Owing to the heavy clay subsoil this type is more retentive of moisture than many soils directly overlying rock. In places, however, the heavy subsoil or so-called "clay bottom" is lacking or indistinctly developed, and here the soil tends to be droughty, especially for such crops as corn.

The following table gives the results of mechanical analyses of samples of the soil, subsoil, and lower subsoil of the Randolph loam:

Mechanical analyses of Randolph loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
2722126	Soil	2.9	8.7	5.6	27.2	12.2	32.0	11.4
2722127	Subsoil	2.0	6.4	4.6	22.8	12.0	32.8	19.2
2722128	Lower subsoil	1.6	5.4	3.8	22.0	11.7	34.5	20.9

BROOKSTON LOAM.

The surface soil of the Brookston loam consists of dark grayish black to brownish black, friable, gritty loam, 7 to 10 inches deep.

The subsurface material consists of a mottled yellow and dark bluish gray loam to light clay loam, containing sufficient sand to have a distinct grittiness. Its color varies from almost golden yellow through dingy yellowish gray to rather dark bluish gray. Below 24 to 28 inches the subsoil is a sticky, yellow and gray mottled, gritty clay loam. The yellow increases with depth and is the dominant color below 24 to 28 inches. Some pebbles occur in the surface soil, and the amount increases generally with depth. In places calcareous material is encountered within the 3-foot section. In some rather poorly drained areas drab may be the dominant color throughout the 3-foot section.

For the most part the Brookston loam occupies small scattered areas throughout the lake-till and beach region of the county, usually near the beach line or near the approaches to the old rock barriers. The topography is level to undulating or sloping. The type almost nowhere has a dead level topography, such as characterizes the Brookston clay, although some fields would be designated as very nearly level. The surface run-off and internal drainage are poor, but owing to the open nature of the soil artificial drainage is readily established.

The Brookston loam is quite productive, but its total area is small. It is used for general farming and to some extent for trucking, to which it seems well adapted. The areas around Clyde and south of Fremont are used to a considerable extent for growing cabbage.

This soil is quite easy to handle. Two-horse plows are generally used, and the land is plowed to a depth of 6 to 7 inches. Fertilizers are used to some extent, especially on cabbage and other truck crops. Acid phosphate results in increased yields, and most farmers feel that fertilization is profitable. Few farms are composed entirely of this type, and an estimate of its selling value is very difficult to make. Well-improved areas are probably valued at $150 an acre, and certain trucking lands are held at nearly twice this price.

In the improvements of this type legumes should be grown more extensively. The use of lime is of doubtful advisability.

The following table gives the results of mechanical analyses of samples of the soil, subsoil, and lower subsoil of the Brookston loam:

Mechanical analyses of Brookston loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
272249	Soil	0.3	2.6	3.8	37.1	11.4	28.3	16.3
272250	Subsoil	.2	3.8	7.0	42.2	10.9	20.6	15.3
272251	Lowersubsoil	1.1	7.4	8.4	28.8	12.7	26.0	15.7

BROOKSTON SILTY CLAY LOAM.

The surface soil of the Brookston silty clay loam consists of 7 or 8 inches of almost black, light silty clay loam or heavy silt loam. The surface soil is not plastic but it contains a rather large proportion of clay, which causes it to clod if plowed when wet and results in the formation of surface cracks on drying. The subsurface material is a plastic, bluish-gray silty clay loam, containing a few yellow mottlings and some iron streaks below 15 or 16 inches. At 20 to 22 inches the material becomes yellowish, and this color increases with depth. Below 30 inches yellow is usually the dominant color. The material is not calcareous within the 3-foot section.

The Brookston silty clay loam occurs in small scattered areas in the southeastern corner of the county. It has a flat to basinlike surface, as it occupies the basins of former shallow lakes. The small areas in section 12, north of Bellevue, along the county line, are slightly undulating and have a dominant yellow color throughout the subsoil. They represent what might be designated a better drained phase.

The natural surface and internal drainage of this soil is very poor, but is easily supplemented by artificial means owing to its favorable structure and texture.

This is an inextensive type, but it is recognized as a valuable general-farming soil, well suited to corn. It is all under cultivation at the present time and in a high state of improvement. Corn yields 40 to 50 bushels per acre, wheat 20 to 25 bushels, and oats 35 to 40 bushels. Clover also does well, yielding 1 to 1½ tons per acre. This soil must be carefully handled when wet, but it readily works into a good seed bed. Some fertilizer has been used on wheat to good advantage, but fertilization has not been generally extended to other crops, as satisfactory yields are obtained without their use.

The following table gives the results of mechanical analyses of samples of the soil, subsoil, and lower subsoil of the Brookston silty clay loam:

Mechanical analyses of Brookston silty clay loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
272232	Soil	1.0	3.4	2.5	11.1	9.7	43.9	28.3
272233	Subsoil	1.4	3.0	2.0	10.1	9.3	39.0	35.3
272234	Lower subsoil	5.5	9.7	4.4	23.1	10.3	40.4	6.7

BROOKSTON CLAY LOAM.

The Brookston clay loam, to a depth of 7 to 10 inches, consists of a dark-gray to black, mellow, friable clay loam, occasionally con-

taining some gravel and pebbles. Almost every texture between a silty clay and a fine sandy loam is necessarily included within this type as mapped. The subsurface material is a mottled yellow, drab, and gray, plastic clay loam, distinctly less heavy and plastic than the corresponding layer of the Brookston clay. As a rule drab is the dominant color, the yellow being frequently lacking, although in some cases it is the dominant color. Below 20 to 24 inches the material is more gritty and friable and more yellow, but in many places drab mottlings persist throughout the 3-foot section. Pebbles increase in abundance in the extreme lower part of the 3-foot section and calcareous material is quite frequently encountered here, more frequently than in the Brookston clay.

As the type occupies an intermediate position between the Brookston clay and Brookston loam, it grades toward them in many places. In some cases the lower subsoil is quite heavy and in others it is gritty and friable. Color variations of equal diversity are encountered, but on the whole the type has an almost black surface soil, a black, slightly yellow streaked, subsurface layer, and a yellowish lower subsoil.

The Brookston clay loam occurs in small areas widely scattered throughout the lake-till region. It usually occupies the slightly higher lying areas near the beaches or old rock barriers, and it does not occur in large areas well out in the old lake plains. Its topography is nearly level, but not flat or floorlike as in the case of the Brookston clay. Where it adjoins the clay it is slightly higher lying and faintly undulating.

Both surface run-off and internal drainage are poor, although not so markedly deficient as in the Brookston clay, and artificial drainage can be effected much more easily.

The Brookston clay loam is a valuable soil agriculturally, but it is not important because of its small extent. Practically all of it is under cultivation and in a high state of improvement. It is used for general agriculture, with corn as the leading crop. There are some excellent yields of alfalfa on this soil, and farmers report that the crop can be grown without any fertilizer treatment. The type is more productive and more easily farmed than the Brookston clay. It is handled without difficulty with the heavier types of farm implements. An excellent seed bed is readily obtained if care is taken not to plow the soil when wet. Commercial fertilizers are used to a small extent, and the amount is increasing from year to year. The farmers report good results from the use of fertilizers, especially the "straight acid goods," i. e., acid phosphate.

Well-improved farms on the Brookston clay loam are held at $150 to $175 an acre. Very little of this land is changing hands.

In improving this type it is essential to follow a rotation that provides for the growing of a legume once in every four or five years. Deeper rooted crops should also be grown. Alfalfa could readily be made a successful crop.

Some small areas of the Brookston clay loam are underlain by bedrock at depths of 20 to 30 inches. These areas occupy positions adjacent to the rock hills. The soil is similar to the typical Brookston clay loam agriculturally, except for the obstruction of drainage by the bedrock.

The following table gives the results of mechanical analyses of samples of the soil, subsoil, and lower subsoil of the Brookston clay loam:

Mechanical analyses of Brookston clay loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
272252	Soil	0.4	1.6	1.3	11.8	12.6	52.1	20.3
272253	Subsoil	.5	2.2	1.7	11.8	10.5	46.7	26.8
272254	Lower subsoil	.4	1.9	1.2	9.4	7.8	52.3	27.1

BROOKSTON CLAY.

The Brookston clay to a depth of 7 or 8 inches is a dark-gray to black clay loam or clay, containing a small amount of grit. Although the percentage of clay is quite high the material is granular and somewhat friable, owing to a crumb structure. The subsurface layer is a heavy, plastic clay, ranging from dark drab to dingy yellow and drab streaked. It contains some sand and occasional fragments of fine gravel. This material is distinctly heavier and more plastic than the surface soil, but it lacks the smooth, greasy plasticity characteristic of the Newton silty clay. At 20 to 22 inches the material becomes more mottled with yellow and slightly more gritty and friable, and at 30 inches it is usually a yellow, slightly gritty clay. Small particles of calcareous material are sometimes found between 30 and 36 inches, but as a rule the soil is not calcareous within the 3-foot section. The grittiness, however, indicates an approach to the till, and calcareous, unweathered till is always encountered at 3½ to 4 feet.

In certain places where drainage is better than the average, as near streams or where the type merges into better drained soils such as the members of the Miami series, the surface material is lighter colored and shallower than typical and the subsurface layer contains more yellow. Where the natural drainage is poor the surface material may be deeper and darker and the subsurface and

lower subsoil layers predominatingly drab. This is usually the case in small depressions between ridges or slightly higher-lying soils, where the surface material is sometimes 10 inches deep. In such places the soil represents a gradation toward the Clyde series. Where the type grades toward sandier soil it contains more coarse material than typical, and as mapped it includes many patches of fine sandy loam and fine sand, 8 to 10 inches deep, near the border of the areas.

The largest areas of the Brookston clay occur in the western end of the county, particularly west of Gibsonburg and around Woodville. Smaller areas are found in Scott Township and in the central part of the county, where this is the dominant type in the former lake bed between the old beaches and the lacustrine deposits. The topography is dead level, the slightest undulation being accompanied by a change in color or texture or both. The surface drainage and underdrainage are very poor. The type was a series of flats and swales until reclaimed within the last 50 years by an extensive system of drains.

This is an extensive and important type agriculturally. Most of it is cleared and in a high state of cultivation, but patches of the original growth of elm, hickory, ash, oak, and beech still remain. The original growth was quite heavy in most places, and much lumber was cut. The soil is highly prized for general farming, especially for corn, wheat, and clover. A four-year rotation, consisting of corn, oats, wheat, and clover, is followed by most farmers. They recognize the inadvisability of planting corn two years in succession. The crop is preferably grown on clover sod. Considerable live stock is kept on the average farm, and many farmers feed practically all the grain and hay produced. In the past sugar beets have been grown successfully, but beet growing died out because of unstable and unsatisfactory local market conditions. Corn yields 55 to 80 bushels per acre, oats 30 to 40 bushels, and wheat 15 to 25 bushels.

Extreme care is required in handling this type. One of the first needs is adequate drainage. Large ditches and extensive tiling systems have been installed. The drains are frequently 100 feet apart, but more satisfactory results are obtained when the interval is 50 feet. Some farmers even assert that the results justify placing the tiles 2 rods apart. The preferred depth is 30 to 36 inches. According to some farmers, tillage operations may be carried on with greater ease after tile drainage has been installed. This soil can not be plowed safely except when it is at its optimum moisture content. If plowed when a little too wet and then allowed to bake it is almost impossible to prepare a good seed bed until the soil has been allowed to lie over winter and "slake." The soil has a marked property of

granulation, and breaks into hard, rather sharp-edged cubical fragments. These form a rather loose mass which can be easily pushed around with the foot, giving rise to the name of "buckshot land." The soil in rain-beaten plowed fields crusts slightly and on drying cracks into squares a few inches in diameter. Plowing is usually done with two-horse breaking plows or tractors. Little ground is fall plowed, although good results have been reported where this has been done.

Fertilizers are used to a small extent, principally on wheat, with good results. The general opinion seems to be that acid phosphate gives the most profitable returns. In wheat fields partly fertilized and partly unfertilized the difference in growth is always noticeable. Farmers, however, report some cases in which fertilization has produced little or no increase in yield.

Land values on the Brookston clay range from $150 to $200 an acre, depending on location, improvements, and proximity to good roads. A few well-improved and tile-drained farms are reported to have sold at $225 an acre.

The principal need of this soil is adequate drainage and the use of a proper crop rotation to keep the soil in a granular condition. Alfalfa does particularly well where adequate drainage is provided, and other deep-rooted crops, such as sweet clover, which grows wild in a number of places, should be grown to a greater extent. The practice of growing clover once in four years is excellent, and sod land should be used for corn even more extensively than at present.

Numerous small areas of Brookston clay near the rock hills are underlain by limestone at depths ranging from 20 to 30 inches. These areas are very irregular, the rock floor being apparently somewhat discontinuous.

The soil is similar to the typical Brookston clay, and the agricultural value is about the same, except that the limestone rock is sometimes an obstacle in laying tile drains.

The following table gives the results of mechanical analyses of samples of the soil, subsoil, and lower subsoil of the Brookston clay:

Mechanical analyses of Brookston clay.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
272224	Soil	1.4	3.6	2.5	14.2	10.6	43.0	24.7
272225	Subsoil	.9	3.1	2.2	11.0	8.9	36.4	37.6
272226	Lowersubsoil	1.5	3.8	2.4	10.2	9.5	37.9	34.7

MILLSDALE STONY CLAY LOAM.

The Millsdale stony clay loam consists of 7 or 8 inches of black, friable loam to light clay loam, underlain by yellow to brownish-yellow clay loam which is slightly mottled with bluish gray to a depth of 12 to 14 inches. At this depth bedrock is usually encountered, although in some places it is not reached above 18 to 24 inches, in which case a thin layer of friable, calcareous material directly overlies it. Much of the type is so thickly interspersed with protrusions of the bedrock that tillage is impossible, and such areas are shown on the map by means of rock-outcrop symbols. The remainder of the type is quite thickly strewn with angular to subangular fragments of limestone, varying from 1 to 6 inches in diameter. The more stony areas are indicated on the map with stone symbols.

The topography is generally flat to basinlike, but a few areas occupying low swells and slopes of the stony ridges are gently undulating. The surface drainage is poor and the internal drainage very poor. Part of the type as mapped is peaty in nature.

The Millsdale stony clay loam has a low agricultural value. Some areas are farmed, and where a proper seed bed has been prepared fair crops are obtained. The type has a higher value for pasture, other things being equal, than the Randolph stony loam.

The following table gives the results of mechanical analyses of samples of the soil and subsoil of the Millsdale stony clay loam:

Mechanical analyses of Millsdale stony clay loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
2722122	Soil	1.5	4.4	4.4	18.5	10.1	39.3	21.7
2722123	Subsoil	1.4	4.0	4.6	31.2	10.2	31.7	16.5

NEWTON SANDY LOAM.

The Newton sandy loam, to a depth of 7 to 9 inches, is a dark-gray to black sandy loam containing a large amount of organic matter, which gives rise to a loose, friable structure. Moist, freshly plowed fields appear black, and this has given rise locally to the term "black sand." The surface material is a rather dark bluish gray sandy loam, containing some yellow mottlings, and having a slightly more coherent structure than the surface soil. It gives way at 18 to 22 inches to a similarly structured yellowish sandy loam, which contains some bluish-gray streaks and mottlings and dark iron stains. Slightly

rounded pebbles are found on the surface and throughout the 3-foot section.

The Newton sandy loam occurs for the most part in Ballville Township, south of Fremont, just inside the old Warren Beach, which is but a short distance south of the county line and enters the county just east of the Sandusky River. A few small areas are scattered over the county. The surface is level, and the natural drainage is very poor, but owing to the open, porous structure artificial drainage is easily effected. All the type under cultivation at the present time (1917) is improved with tile drains.

The greater part of the large area in Ballville Township is cleared and well improved. The type is highly prized for general farming, to which it is largely devoted. Corn and wheat are the principal crops, followed by oats, clover, and cabbage. Corn yields 60 to 70 bushels per acre, wheat 25 to 30 bushels, and oats 35 to 45 bushels.

This soil is easily plowed and put in good tilth for seeding. Fertilizers are used quite generally, especially on wheat, and give good results. They should be more extensively used in connection with the growing of legumes, which do well on this soil when it is properly tile-drained. More attention should be given to the home mixing and preparation of fertilizers, in order that the expensive ready-mixed products may be supplemented by cheaper and better materials. The type would be considerably benefited by a more extended use of tile drains.

In the following table are given the results of mechanical analyses of samples of the soil, subsoil, and lower subsoil of the Newton sandy loam:

Mechanical analyses of Newton sandy loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
272212	Soil	1.9	13.7	16.0	38.1	6.8	16.4	7.2
272213	Subsoil	1.5	11.4	15.2	37.9	8.2	17.4	8.5
272214	Lower subsoil	2.2	13.4	15.3	35.0	6.9	17.4	9.7

NEWTON FINE SANDY LOAM.

The surface soil of the Newton fine sandy loam consists of 7 to 10 inches of grayish-black, mellow fine sandy loam. In some of the better-drained areas the material has a brownish cast. The subsurface soil consists of a mottled yellow and rather dark bluish gray, friable fine sandy loam. The subsoil, encountered at a depth of 20 to 24 inches, is more compact and yellowish, the lower subsoil becoming a yellow clay loam slightly mottled with bluish gray. In

the extreme lower part of the 3-foot section the amount of coarse material increases. Some slightly rounded pebbles are found on the surface and throughout the 3-foot section.

The areas mapped as Newton fine sandy loam in the western part of the county are finer in texture than those farther east, and in places the texture approaches a very fine sandy loam. There is considerable range in color in the subsoil of this type. In the more undulating areas the subsurface soil and subsoil are frequently golden yellow, with only traces of drab. In other places where the type occurs as narrow strips near the foot of the ridges the subsoil is frequently quite blue in color. Numerous areas of Newton fine sand, too small to be indicated on the map, are included with this type. On the other hand, where it adjoins the Brookston clay the subsoil becomes heavier than typical and the plastic subsoil material is found nearer the surface.

The Newton fine sandy loam occupies small scattered areas near the foot of the old beach lines and a few areas farther out in the old lake plains. The topography is level, gently sloping, or faintly undulating. Surface drainage is poor to fair, but the internal drainage is everywhere rather poor. Owing to the open structure, however, artificial drainage is easily provided.

This soil is well adapted to cabbage, potatoes, tomatoes, and other truck crops, and the areas southeast of Fremont, in Ballville and Green Creek Townships, are largely devoted to trucking. Many of the small areas in the western part of the county, where heavy soils predominate, are used for the growing of potatoes for home use. Many areas of the type too small to map are used for this purpose.

In small depressions scattered throughout the sandy region of the county the soil is really Maumee fine sandy loam, instead of Newton. It is quite similar to the Newton soil in most respects, but the bluish-gray fine sandy loam subsurface layer becomes streaked with brown iron stains below 20 inches, and frequently contains iron concretions. There is little variation in the subsoil, although in places it may be slightly lighter textured.

The Maumee fine sandy loam occurs in basinlike areas whose natural drainage is so poor that large amounts of organic matter have accumulated in the surface soil. It is used to a considerable extent for cabbage and corn, and it is quite well adapted to both these crops. Its principal need is tile drainage. In some depressions outlets are not readily available, but elsewhere drainage is not difficult.

The following table gives the results of mechanical analyses of samples of the soil and subsoil of the Newton fine sandy loam:

Mechanical analyses of Newton fine sandy loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
2722137	Soil	0.2	2.6	4.2	41.4	21.7	22.1	7.5
2722138	Subsoil	.6	2.7	3.6	38.6	26.4	19.1	8.8

NEWTON VERY FINE SANDY LOAM.

To a depth of 8 to 11 inches the Newton very fine sandy loam consists of a blackish, smooth, very fine sandy loam, high in organic matter. The subsurface layer is a dingy-yellow to dark grayish yellow streaked, rather compact fine sandy loam to very fine sandy loam. Below about 20 inches the yellow becomes more prominent and is the dominant color in the lower subsoil, although in most places grayish-blue mottlings persist to 36 inches. As a rule the texture becomes a fine sandy clay at 27 to 29 inches. The entire 3-foot section is free from pebbles or stones of any kind, and possesses a characteristic smooth feel.

This type is on the whole quite uniform. The areas north of Havens and west of Muskellunge Creek vary somewhat in having a slightly undulating topography, with a coarser and lighter colored surface soil on the crests of the ridges, while the soil in the depressions is slightly darker and heavier than typical. Just west of these areas, in sections 2 and 3, the surface becomes flat and the texture a very fine sandy loam. The large area northeast of Fremont has a slightly higher content of fine sand.

The Newton very fine sandy loam occurs near the outer edge of the extensive lacustrine deposits, but extends farther into the old lake plain than the fine sandy loam type. Its surface is level to very faintly undulating, and natural drainage is very poor. Owing, however, to the light texture and open nature of the subsoil, effective artificial drainage is easily established.

This is a fairly important soil agriculturally, owing to its productiveness. It is all cleared and in a high state of improvement. The type is prized for general farming and also for trucking and gardening.

Where it is used for general farming corn is the most important crop, with wheat probably second. In some regions the type is used largely for the production of truck crops. Cabbage seems to do especially well. Corn yields 55 to 70 bushels per acre. The soil is easily handled, and low yields are much more rare than on some of the heavier types. The soil is plowed to a moderate depth, and in preparing the seed bed some planking, dragging, and rolling is done.

Fertilizers are used on this soil to some extent, and excellent results are obtained, especially with wheat.

Land values on the Newton very fine sandy loam range from $150 to $175 or even $200 an acre.

A rotation, including a legume, such as red clover, which grows luxuriantly, should be followed on this soil, and this rotation should be supplemented by the systematic use of fertilizers. It is not likely that liming would be profitable, except possibly in connection with sensitive crops, such as alfalfa. Corn can be grown for several years in succession without serious injury to the soil, but this practice is not to be commended. It is the opinion of some farmers that new areas will produce excellent yields without fertilization for five or six years, but that thereafter fertilizers are needed if the yields of corn and wheat are to be maintained. Alfalfa could probably be grown on this type where drainage is adequate.

In the following table are given the results of mechanical analyses of samples of the soil, subsoil, and lower subsoil of the Newton very fine sandy loam:

Mechanical analyses of Newton very fine sandy loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
2722110	Soil	0.0	0.2	0.2	17.9	64.3	14.2	2.9
2722111	Subsoil	.0	.1	.3	47.3	38.1	9.8	3.5
2722112	Lower subsoil	.0	.1	.2	22.5	68.8	6.5	1.4

NEWTON LOAM.

The surface soil of the Newton loam, often known as "black land," consists of 8 to 10 inches of mealy fine-textured loam, black or in places very dark brown in color. The subsurface material is a yellow and light-drab mottled loam, similar in texture to the surface soil, but less mellow owing to an absence of organic matter. It becomes slightly heavier below 24 inches and is slightly sticky, but the change to this deeper subsoil is extremely gradual, the absence of zonation being one of the characteristics of the type.

The Newton loam occurs well out in the lake region and probably represents deposits formed in slightly deeper water than those giving rise to the Newton very fine sandy loam. The type is closely associated with the Newton clay loam and silt loam, and it is difficult to separate them in mapping. In places where the loam is mapped, it is simply the dominant soil.

The surface of this type is level to very faintly undulating, as in the case of the Newton clay loam and silt loam, but lacks the floor-

like characteristic which is so pronounced in the case of the Newton silty clay. The drainage, both surface and internal, is very poor, but artificial drainage can be quite readily effected.

The Newton loam is highly prized for general farming, but owing to its small extent it is of minor importance. Practically all of it is cleared and in a high state of cultivation. Corn is probably the leading crop, although a large acreage is devoted to wheat. Oats and clover are also grown in the rotation. Because of the excellent grain-producing power of this soil there is a tendency to keep considerable live stock, consisting of beef and dairy cattle and hogs. Almost no sheep are raised. Corn yields 50 to 75 bushels per acre, wheat 25 to 35 bushels, and oats 35 to 50 bushels. Farming methods on this type are thorough. Plowing and other operations are done with up-to-date machinery and a good seed bed is readily prepared. Commercial fertilizers are used to some extent on wheat, with good results. The use of fertilizers is comparatively new, and no particular system has been adopted.

Land values on the Newton loam range from $125 to $175 an acre. Well improved farms along good roads or near towns often bring $200 or more an acre.

Corn should be grown more extensively on this type and fertilizers containing acid phosphate as the principal ingredient should be used for the profitable production of this crop. In view of the ease with which clover can be grown it seems almost unnecessary to purchase nitrogenous fertilizers.

Newton loam, gravelly-subsoil phase.—The Newton loam, gravelly-subsoil phase, consists of 7 to 10 inches of black, friable, mellow loam, underlain by a yellow, rather heavy loam to light clay loam containing an appreciable quantity of gravel. The subsoil, which begins at 20 to 22 inches, consists of a calcareous clay loam in which gravel constitutes about 50 per cent of the mass. As in all beach soils the gravel is small and well rounded, so that the mass may be readily penetrated with a soil auger.

The phase as mapped shows considerable range in texture. In numerous small, unimportant areas the surface soil is a fine sandy loam and the subsoil a loam. Small areas are also encountered which have a fine sand surface soil and a fine sandy loam subsoil.

The Newton loam, gravelly-subsoil phase, occupies widely scattered areas throughout the beach region in the southwestern, western, and eastern parts of the county. It occurs in small flat areas with only a few low swells and slopes. Drainage, both surface and internal, is very poor. In some of the more poorly drained areas gray mottlings occur in the subsurface layer. This phase is not extensive, but it is highly prized for general farming. It produces good crops of corn and oats, and is said by many farmers to be an

excellent wheat soil, yields being reported to run as high as 35 to 40 bushels per acre in favorable years. Where proper drainage has been provided alfalfa grows satisfactorily. Potatoes are successfully grown on some of the more sandy areas.

The following table gives the results of mechanical analyses of samples of the soil, subsoil, and lower subsoil of the typical Newton loam:

Mechanical analyses of Newton loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
272267	Soil	0.2	0.3	0.3	24.0	43.5	25.0	6.9
272268	Subsoil	.0	.4	.2	23.5	44.0	20.8	11.6
272269	Lower subsoil	.0	.3	.4	19.5	34.6	24.9	19.7

NEWTON SILT LOAM.

The Newton silt loam, to a depth of 8 or 9 inches, consists of a grayish-black, friable, mealy silty loam which contains sufficient clay to be somewhat sticky when wet. The subsurface layer is a friable silty clay loam, yellow and slightly streaked with grayish drab, the mixing of the two colors giving a dull-yellow appearance. The texture becomes very slightly heavier with depth, but the change is so gradual as to be almost imperceptible. Below 20 to 24 inches the material is typically a rather heavy silty clay loam, but in some cases the texture is a clay loam, and in a few areas a dull-brown very fine sandy loam, free from gravel and coarser grit, is encountered in the lower part of the 3-foot section, probably representing the unaltered lacustrine material which elsewhere weathers into the Newton silt loam. Some iron concretions may occur in the lower part of the 3-foot section. The surface material of the Newton silt loam is quite uniform in color.

Slight variations in texture occur in this soil. In some cases the clay content increases and the soil grades toward the Newton clay loam. In other places the content of very fine sand increases and the soil resembles the Newton loam, several included areas really representing minor developments of the latter type. The Newton loam, clay loam, and silt loam are so closely associated that it is impossible to map out all the small areas of the different types.

The Newton silt loam occurs mainly in the transition zone between the till soils and the purely lacustrine deposits. Small areas are also found in the region of the lacustrine soils along the Sandusky River southwest of Fremont. It has a level to very faintly undulating surface, and is poorly drained. In its natural state the surface is

seldom sufficiently free from excess water to permit tillage, and most of the type has been reclaimed by means of ditch and tile drains.

This soil is highly prized, and practically all of it is cleared and farmed. Corn is perhaps the most important crop, but considerable oats, wheat, and clover are grown. Corn ordinarily yields about 60 bushels per acre, wheat 25 to 30 bushels, and oats 35 to 40 bushels.

The Newton silt loam is not difficult to handle, and plowing, harrowing, and cultivating are performed with the ordinary implements.

Fertilizers are used to only a small extent, applications being largely confined to wheat. The practice of fertilization is so new that no definite treatment has been adopted by the farmers.

Land values on this type range from $150 to $175 an acre, with some of the more improved areas selling for $200 an acre.

One of the best uses that can be made of this type is a system of farming in which corn is the main cash crop. The best farmers, however, realize that corn should not be grown continuously, and that the rotations should always include a legume once in four or five years, this to precede the corn crop if possible. Fertilizers can probably be used to advantage, but liming is of doubtful value except on those areas that seem ill-suited to red clover. Alfalfa can probably be grown successfully, but only where thorough drainage is provided and acidity of the soil corrected.

NEWTON CLAY LOAM.

The Newton clay loam, to a depth of 8 to 10 inches, consists of a black, friable, smooth clay loam, underlain by a very fine sandy clay loam, which is streaked and mottled with rather light bluish gray and yellow, and which becomes slightly heavier as it merges into the subsoil, at 20 to 22 inches. The subsoil contains appreciably more yellow, which is usually the dominant color in the lower 16 inches of the 3-foot section. The different layers of material are not sharply defined, the absence of distinct zonation being one of the characteristics of the Newton series. Brown iron stains and iron concretions are found throughout the 3-foot section, but are usually more prominent in the third foot.

The Newton clay loam occurs well out in the lake plain, generally in small areas closely associated with Newton loam and silt loam and the deeper and heavier lacustrine deposits. It sometimes occurs as a transition type between the Newton silty clay and the Brookston clay. It has a level to faintly undulating surface, and the natural drainage is inadequate for farming.

This soil is highly prized for general farming, and the original tree growth of elm, ash, sycamore, maple, and beech has largely been

removed. Corn is probably the most important crop. The type is recognized as a good corn soil, and the crop may safely be grown more years in succession than on such soils as the Newton silty clay. Wheat, oats, and clover do well and are grown in rotation with corn. Corn yields 50 to 70 bushels per acre in normal years, wheat 20 to 35 bushels, and oats 35 to 45 bushels.

In handling this soil the farmers recognize that it should not be plowed when wet. Under proper moisture conditions it is readily worked up into a mellow seed bed. Artificial drainage is always provided before any attempt is made at farming. Some fertilizer is used but no definite system of fertilization has been adopted. Liming has been done on a small scale, but has not proved very beneficial.

Few farms are composed entirely of this soil. It has a slightly higher value than the Newton silty clay, and well-improved areas are held at about $150 or even $200 an acre.

To improve this soil legumes should be grown more extensively, and if possible plowed under, to loosen the surface soil. The use of fertilizers would probably be beneficial, acid phosphate apparently being the most desirable ingredient. Liming is of doubtful value, except possibly in connection with very sensitive crops such as alfalfa or sweet clover, and it is doubtful whether it is necessary even for these. Alfalfa can probably be grown successfully where the drainage is adequate. The type is naturally an excellent corn soil.

NEWTON SILTY CLAY.

The surface soil of the Newton silty clay consists of 6 to 8 inches of dark-gray to black, heavy silty clay loam to silty clay. The subsoil throughout the 3-foot section is a bluish-gray, greasy, plastic clay, streaked with yellow. The material is almost entirely free from grit, and there is a striking absence of zonation, in direct contrast to the subsoil of the Brookston clay. Furthermore, the subsoil is a lighter bluish gray than in the Brookston type, and the yellow is of a more rusty-brown shade. There is no evidence of calcareous material or till within the 3-foot section. Iron concretions occur throughout the subsoil, but are slightly more prominent in the third foot, and the material here may be slightly more iron-streaked. The lacustrine deposits from which this type is formed are usually 3 to 8 feet deep, and as observed in cuts along drainage ditches they show some stratification.

The surface soil is difficult to work, except under the very best moisture conditions, when its marked property of granulation aids in forming a satisfactory seed bed. Owing to its compact, waxy nature the type is sometimes spoken of as "black-wax land." It

cracks badly on drying, and crops sometimes are injured, as large cracks may extend to a depth of nearly 2 feet, causing the lower subsoil to dry out.

The Newton silty clay is developed far out in the old lake region. The largest area is in the north-central and northeastern parts of the county, a large development extending eastward from Lindsey to Whitmore and to the county line. Small areas are mapped in the area of lacustrine soils bordering the Sandusky River. A level, floorlike surface, with little variation, is one of the characteristics of this soil. Where there is even a slight rise in topography the type gives way to the Lucas silty clay loam or silt loam. The natural drainage, both surface and internal, is consequently very poor; and owing to the close, dense structure of the subsoil, artificial drainage is difficult.

This is one of the most extensive and important soils in the county. Although it is heavy to work, its favorable topography and rather high productiveness make it quite desirable for general farming, and a large proportion of the type is under cultivation. The scattered woodlots which remain are composed principally of elm, with some beech, sycamore, hickory, and maple.

The type is used for general farming, corn, oats, wheat, and clover being the most important crops. Some sugar beets are grown, but the acreage of this crop is limited by unfavorable labor and market conditions. Corn yields 50 to 60 or even 70 bushels per acre, and occasionally as much as 80 bushels. Wheat yields 20 to 30 bushels per acre, and oats 35 to 45 bushels. Clover grows very luxuriantly and frequently yields 2 tons per acre at a cutting.

In handling the Newton silty clay it is generally recognized that very elaborate systems of open ditches and tile drains must be installed. The fall is very slight and tile can not be properly laid without the aid of accurate surveying. Farmers report that the lines of tiles must be closer together than on the Brookston clay, owing to the more compact structure of the Newton soil or its flatter surface, and drains are in many cases placed at intervals of two rods. The tiles are usually laid 28 to 36 inches deep. Plowing is done to only a moderate depth and is accomplished with two-horse plows and tractors. Fall plowing is practiced to some extent. The heavy soil slakes and falls to pieces under the action of freezing and thawing so that a good seed bed can be produced quite readily in the spring.

Farmers understand that it is inadvisable to plant this soil continuously to corn. The preferred practice is to turn under clover sod for corn, and to grow the crop only one year in the rotation.

Some fertilizers are used on this type, but farmers have made little study of their respective values.

Farms composed of the Newton silty clay are valued at $125 to $150 an acre. Some rather poorly improved tracts can be purchased for $100 or less an acre, while well improved and drained farms near towns or on good roads are held at $200 an acre.

Drainage should be given study by farmers on this soil. It is probable that best results can not be obtained unless the drains are placed at intervals of less than 50 feet. The practice of plowing up clover sod for corn should be followed more generally. Liming is probably not necessary, as red clover grows luxuriantly and alfalfa is apparently a dependable crop where drainage is adequate. One of the chief problems in farming is the proper handling of the soil. It is probable that best results are obtained from fall plowing. In Marion County and other regions this soil is invariably plowed in the fall. A second problem is the penetration of the lower subsoil, the structure of which could probably be improved by the growing of deeper-rooted crops. Sweet clover seems to present possibilities along this line, and this forage crop should be experimented with.

The following table gives the results of mechanical analyses of samples of the soil, subsoil, and lower subsoil of the Newton silty clay:

Mechanical analyses of Newton silty clay.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
272218	Soil	0.1	0.3	0.5	5.1	8.2	46.8	39.0
272219	Subsoil	.1	.4	.4	6.1	7.8	40.3	44.8
272220	Lower subsoil	.0	.6	.6	5.3	7.4	34.9	51.3

LUCAS GRAVELLY FINE SANDY LOAM.

The Lucas gravelly fine sandy loam, to a depth of 7 to 9 inches, consists of a yellow to yellow-gray, friable fine sandy loam. Small, well-rounded gravel is present in sufficient quantity to give beaten fields the appearance of being strewn with gravel. The subsurface material to a depth of 16 to 18 inches is a brassy-yellow and gray mottled, slightly coherent fine sandy loam, containing as a rule more gravel and coarse sand than the surface soil. The subsoil proper consists of a mixture of clay, sand, and small rounded gravel, the latter constituting perhaps 50 per cent of the mass. The interstitial material is a slightly sticky clay loam, dull brown to brassy-yellow in color and usually mottled with gray. The lower subsoil layer is calcareous, but not so strongly as that of the Belmore loam. Effer-

vescence with mineral acids is frequently slight until the lower part of the 3-foot section is reached.

Some small areas mapped with this type approach yellowish-brown in color. This latter variation represents a gradation toward the Belmore fine sandy loam, and where the brown color is distinctly developed the soil is mapped as the Belmore loam. Frequently the lower part of the 3-foot section contains a stratum of heavy, dingy-gray, impervious clay, and elsewhere this is nearly always reached at slightly greater depths. In places the material rests on bedrock at depths slightly greater than 3 feet. In the areas southwest of Millersville the underlying heavy clay is encountered in some places at a depth of only 2 feet.

The Lucas gravelly fine sandy loam occurs largely in the region of rock barriers and sand ridges in the western part of the county, and represents shallow beach deposits formed probably along former islands and secondary beaches. It occupies widely distributed small areas and strips, and does not exist in long ridges like the Belmore types. The topography is in many places level, but grades to gently undulating on low, flat swells or shelflike situations. The surface drainage is fair, but the internal drainage poor. The impervious clay subsoil which underlies the type at a depth of 3 to 4 feet retards the movement of soil water, and the statement is frequently made by farmers that this is the wettest soil in the county. It is often spoken of as "cold sand land."

This type is of minor importance. Owing to its occurrence in small, isolated areas no particular type of agriculture has been developed on it, but farmers recognize that with proper tile drainage and fertilization it makes good potato land. It is also well adapted to the production of fruits. Following the improvement of drainage the soil should be planted to potatoes once in three or four years with an intermediate cropping to wheat and clover or wheat, oats, and clover. Clover would no doubt be benefited by liming, and following the application of lime sensitive crops, such as alfalfa, could doubtless be grown.

The following table gives the results of mechanical analyses of samples of the soil, subsoil, and lower subsoil of the Lucas gravelly fine sandy loam:

Mechanical analyses of Lucas gravelly fine sandy loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
2722116.....	Soil.....	0.0	0.1	0.3	47.3	38.1	9.8	3.5
2722117.....	Subsoil.....	3.6	9.4	11.5	28.3	9.7	25.2	12.3
2722118.....	Lower subsoil...	.7	7.6	13.9	37.2	10.6	16.1	13.7

LUCAS FINE SAND.

To a depth of 8 to 10 inches the Lucas fine sand is a light-brown to yellowish-brown fine sand. Underlying this is a golden-yellow to straw-colored, smooth, incoherent, fine sand very similar to the surface in texture and structure. Below 20 to 24 inches the material becomes slightly sticky and with slight increase in depth grades into a fine sandy loam and a few inches deeper into a fine sandy clay. At 28 to 30 inches the subsoil becomes a heavy, compact, dull yellowish brown clay, almost free from grit. Indistinct gray mottlings are sometimes observed in the transition zone. There is some variation in the depth to the clay, which in small areas may not be encountered within the 3-foot section. There are also a few areas in which the sand seems to rest directly on the clay, the transition zone being not thicker than an inch or two.

The Lucas fine sand occurs principally where fine sand overlies the glacial till which gives rise to the Miami soils, but small areas are scattered throughout the county where the fine sand overlies clays of a different nature; for instance, that which gives rise to the Brookston soils. The type has an undulating to rolling surface, and artificial drainage is usually unnecessary.

This is not an extensive or important soil. Except for a rather large development southwest of Bellevue it forms very small areas. It is used for general farming and is slightly more productive than the Dunkirk fine sand, with which it is closely associated. The type can be improved in the same way as the Dunkirk soil. It is probable that even better results will be obtained from the growing of alfalfa or deep-rooted crops, and the type is also more retentive of fertilizers and less droughty than the Dunkirk fine sand.

The following table gives the average results of mechanical analyses of samples of the soil, subsoil, and lower subsoil of the Lucas fine sand:

Mechanical analyses of Lucas fine sand.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
272215, 272282.	Soil	0.1	1.3	2.9	52.3	25.7	13.2	4.7
272216, 272283.	Subsoil	.1	1.1	2.7	54.2	26.4	11.7	4.3
272217, 272284.	Lower subsoil	.3	1.5	1.7	35.3	28.3	20.9	12.2

LUCAS VERY FINE SANDY LOAM.

The Lucas very fine sandy loam, to a depth of 7 or 8 inches, is a yellow-tinted, light-brown very fine sandy loam, containing so little sand of the coarser grades as to have a very smooth, almost mealy feel. The subsurface layer is a yellowish-brown, smooth, compact,

very fine sandy clay which grades below into interbedded layers, 1 to 2 inches thick, of clay and very fine sand. In the more nearly level areas there is some mottling in the subsurface layer. Calcareous material is sometimes found in the lower part of the 3-foot section.

The Lucas very fine sandy loam occurs near the outer border of the continuous lacustrine deposits, principally in one fairly large area just south of Ballville. It has an undulating to sharply rolling topography, resulting from dissection along the streams, and natural drainage is for the most part good.

This soil is used for general farming, and no special type of agriculture has been worked out. The soil is easily tilled and quite productive, giving good average yields of corn, wheat, and oats. The more rolling areas are somewhat subject to erosion.

Lucas very fine sandy loam, coarse phase.—The surface soil of the Lucas very fine sandy loam, coarse phase, consists of 7 to 10 inches of yellowish-gray, mellow, friable, smooth, fine sandy loam to very fine sandy loam. This is underlain by a slightly heavier, more brassy yellow fine sandy loam, which usually is slightly mottled with gray. The subsoil, which begins at 15 to 18 inches, is a gritty clay loam. Frequently the material becomes more friable in the lower part of the 3-foot section, but no pebbles and stones are encountered. Calcareous material is often found in the lower part of the heavy subsoil layers just above the more friable material, and this latter stratum also frequently shows a slight effervescence with mineral acids.

This soil occupies narrow strips along the streams near the outer edge of the continuous lacustrine deposits. It has been formed from the weathering of the lighter-textured lacustrine materials, which were deposited in only moderately deep waters. The phase usually is closely associated with the Newton silt loam and represents material which under conditions of poor drainage has given rise to the Newton soil.

The surface of the Lucas very fine sandy loam, coarse phase, is undulating to rolling or even sharply rolling. In the latter areas erosion has almost invariably cut through the lacustrine material and exposed some till, so that the soil represents a mingling of the lacustrine material and till and assumes some of the properties of the Miami series. Where such areas are sufficiently extensive they are shown separately on the map as Miami fine sandy loam, heavy-subsoil phase. This is particularly true of the areas south of Fremont in sections 3 and 4, where there is some doubt as to the proper classification of certain areas.

The surface drainage of the Lucas very fine sandy loam, coarse phase, is good, and the subsoil drainage is fairly well developed.

The presence of some mottlings, however, in the subsurface material shows that it has weathered under imperfect drainage conditions. No farm is composed exclusively of this soil, and in general it occupies only small portions of farms through which a stream may pass. It is used either for pasture or for the production of fruit, truck crops, or potatoes. Some of the more undulating areas bordering the darker-colored types are farmed to wheat and oats.

The table below gives the results of mechanical analyses of samples of the soil, subsoil, and lower subsoil of the typical Lucas very fine sandy loam, and of the coarse phase:

Mechanical analyses of Lucas very fine sandy loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
Typical:		*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
2722104	Soil	0.0	0.4	0.4	25.9	41.9	24.4	6.5
2722105	Subsoil	.0	.4	.4	21.1	37.4	30.4	10.0
2722106	Lower subsoil	.0	.2	.2	4.5	27.6	46.3	21.0
Coarse phase:								
272264	Soil	.0	.3	.4	18.8	42.2	30.2	7.9
272265	Subsoil	.0	.2	.2	20.4	40.1	25.8	13.0
272266	Lower subsoil	.0	.1	.3	30.3	25.9	25.0	18.0

LUCAS SILT LOAM.

The surface soil of the Lucas silt loam consists of a smooth, yellowish-gray, heavy silt loam, about 7 inches deep. The surface material is low in organic matter but rather high in clay, and becomes quite compact upon drying. Some iron concretions may be scattered over the surface. The subsurface material is a yellow and light-gray mottled, heavy silt loam to light silty clay loam. At a depth of 15 to 18 inches the yellow becomes more tan in color, the gray mottlings disappear, and the material grades into a heavy silty clay loam which is somewhat compact and plastic when wet and becomes brittle on drying. This heavy layer gives way at about 27 inches to the smooth, friable unweathered material which has evidently given rise to the type. Light specks of calcium carbonate are to be found in the lower part of the heavy subsoil layer, and the friable material in the lower part of the 3-foot section shows a slight effervescence with mineral acids. The calcareous material has evidently been leached from the surface and precipitated below.

The Lucas silt loam as mapped includes a considerable range in texture, grading on the one hand toward the Lucas silty clay loam, where the surface soil is heavier and shallower than typical, and in other areas toward the Lucas very fine sandy loam, the soil being quite high in very fine sand and very friable. The variations fre-

quently occur within short intervals and it is impossible to show them on a map of the scale used.

The Lucas silt loam occurs in small strips throughout the regions of lacustrine material, occupying slightly dissected, better-drained areas adjacent to streams. The most extensive development of the type occurs just east of Fremont. It has an undulating to gently rolling surface and the run-off is good, but the internal drainage is only fair and gives rise to the characteristic gray mottlings of the subsurface layer.

The Lucas silt loam is a relatively unimportant soil. Except for the areas southeast of Fremont it occurs in long strips which make up only small parts of any one farm. It is consequently used to a considerable extent for pasture. The areas southeast of Fremont are farmed to corn, wheat, oats, and some fruit. The type is quite well adapted to wheat and oats, but is not a good corn soil. It is rather hard to work and becomes quite cloddy if stirred when wet.

In the following table are given the results of mechanical analyses of samples of the soil, subsurface, subsoil, and lower subsoil of the Lucas silt loam:

Mechanical analyses of Lucas silt loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
272297	Soil	0.4	1.5	1.0	5.7	21.2	53.5	16.4
272298	Subsurface	.4	1.0	.8	4.0	20.6	44.9	28.2
272299	Subsoil	.1	1.0	.6	3.5	12.8	31.2	50.7
2722100	Lower subsoil	.0	.8	.5	3.9	9.5	44.4	41.0

LUCAS SILTY CLAY LOAM.

The Lucas silty clay loam, to a depth of about 6 inches, consists of a grayish-yellow, light, friable silty clay loam or smooth, heavy silt loam, which possesses a rather velvety feel when dry. This changes quite rapidly into a peculiar tan-colored, heavy, compact silty clay loam or even silty clay, which is marked with large gray mottlings between 7 and 12 inches. The mottlings disappear below 12 inches and the texture gradually becomes heavier. This heavier material shows some stickiness but gives way gradually at 15 to 18 inches to a dull-brown, dense, brittle clay or silty clay. At 28 or 30 inches the material becomes softer and slightly more crumbly and friable, and is quite highly calcareous, probably as a result of the leaching of calcium carbonate from the upper soil. The subsurface and subsoil material on the whole may be designated as very compact and somewhat brittle when dry and quite plastic when wet.

There is more distinct zonation in this type than in such soils as the Newton silty clay. For instance, there is calcareous material in the lower part of the 3-foot section, which is differently colored from the subsurface layer, and there is some slight mottling in the subsurface layer, which between 6 and 12 inches seems to possess a peculiar slightly sticky and compact structure not shown by the lower subsoil. There are some variations in the surface material, and they seem to be somewhat dependent on the topography. Where the suface is slightly more rolling and therefore subjected to more weathering and leaching, the surface soil becomes more silty and friable, and in such places the type might be designated as a shallow silt loam. In these more rolling areas the subsurface layer is more compact and more impervious and the subsoil more highly calcareous. In the more nearly level areas, which represent a gradation toward the Newton silty clay, the surface soil is heavier, the subsurface layer only moderately heavier than the surface soil, and the subsoil but slightly calcareous, occasionally being noncalcareous. Zonation is more pronounced in the more undulating areas.

The Lucas silty clay loam occurs mainly in small areas closely associated with the Newton silty clay. It is derived from the same material which under conditions of poorer drainage gives rise to the Newton soil, and it occurs for the most part in narrow strips near the drainage ways which traverse the large areas of Newton silty clay. Some larger areas exist east of Fremont and between Erlin and Vickery. The topography is undulating to gently rolling. Some of the more deeply dissected areas are quite steep next to the larger drainage ways. The type naturally has good run-off, but the subsoil drainage is quite poor. Owing to the compact structure of the subsoil, artificial drainage is difficult to install, as the tiles do not remove water for any considerable distance on each side of the drains.

The Lucas silty clay loam is of little importance. The small strips bordering the stream north of Fremont are quite largely left in pasture, but some of the areas east of Fremont and around Vickery are farmed to corn, wheat, and oats. The type is not well adapted to general farm crops. Corn often makes quite poor yields. Oats and wheat are more dependable. Tree fruits give fairly good results. Corn probably yields 20 to 30 bushels per acre, oats 20 to 30 bushels, and wheat 12 to 20 bushels. Clover yields about 1 ton per acre when a good stand is obtained.

This soil is difficult to handle, as the surface clods very easily. It is usually plowed quite shallow, as the preparation of the seed bed and subsequent cultivation are rendered extremely difficult if the

heavy subsoil material is plowed up. The soil is much more easily pulverized when at the optimum moisture content than when too wet or too dry, and is much inferior to the dark-colored heavy soils in property of granulation.

Owing to the small extent of this soil and its occurrence in long, narrow strips it is difficult to estimate accurately its selling value, but by comparison with the Newton silty clay it would probably be priced at $60 to $80 an acre.

The improvement of this type involves numerous difficulties. In installing tile the drains would have to be placed so close together as to make the cost prohibitive. The addition of coarse material, such as coarse manure and straw, to the surface would probably be very beneficial. Liming would undoubtedly aid in the production of clover. Owing to the small extent of this type it can probably be best utilized, under present agricultural conditions at least, as pasture land and for fruit growing.

The following table gives the results of mechanical analyses of samples of the soil, subsoil, and lower subsoil of the Lucas silty clay loam:

Mechanical analyses of Lucas silty clay loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
2722101	Soil	0.1	1.3	1.0	3.1	10.5	59.2	24.5
2722102	Subsoil	.0	.3	.3	1.8	6.4	39.4	51.8
2722103	Lower subsoil	.3	.3	.2	1.3	6.8	58.0	33.1

WARNERS LOAM.

The surface soil of the Warners loam consists of 7 to 9 inches of dark-gray to black, slightly marly loam to silt loam. The subsurface material is a white to light-gray, loose, pulverulent marl, high in calcium carbonate, varying from 6 to 20 inches in thickness, and underlain by a dull yellowish brown, highly calcareous clay. "Marl rocks" are strewn over the surface and are occasionally abundant enough to interfere with cultivation.

The Warners loam occupies one moderately large area and a few small areas in northeastern Townsend Township, closely associated with the Newton silty clay and clay loam. Its topography is level to gently undulating.

This soil has been cleared and put under cultivation. It produces good yields of corn, oats, and wheat, approximately the same as those obtained on the Newton silty clay. It is much more easily worked than the Newton soil. Some of the area shown as Warners

loam is being dug over for material to be used commercially in the lime industry.

The following table gives the results of mechanical analyses of samples of the soil, subsoil, and lower subsoil of the Warners loam:

Mechanical analyses of Warners loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
272237	Soil	0.9	4.5	2.1	19.5	17.0	50.2	6.1
272238	Subsoil	3.0	12.5	5.8	33.6	23.7	19.4	1.7
272239	Lower subsoil	.0	.2	.1	5.3	16.2	51.6	26.5

DUNKIRK FINE SAND.

The Dunkirk fine sand, to a depth of 7 to 10 inches, consists of a light yellowish brown to straw-colored, smooth fine sand to very fine sand. In plowed fields the soil after a beating rain assumes a rather marked compactness as compared with sands in general. The subsoil is a straw-colored to bright golden yellow, smooth fine sand, continuing throughout the 3-foot section with practically no change, except that iron streaks and concretions are present here and there in the lower part. In some places the subsurface layer shows a suggestion of faint gray mottling, and the lower subsoil is rather brassy yellow in color. Throughout the type there also occur patches which have a heavy subsoil within the 3-foot section. Where these are extensive enough to map separately they have been included with the Lucas fine sand.

As a rule the 3-foot section is remarkably free from pebbles and coarse grit, probably owing to the reworking of the soil by the wind. Where the type grades into the gravelly phase, however, the soil in places contains a small amount of pebbles. Occasionally gravelly material is encountered in the lower part of the 3-foot section, representing a gradation toward either the gravelly phase or the Belmore fine sand. Where practicable these are classed with the latter type rather than with the Dunkirk.

The Dunkirk fine sand is very incoherent and is consequently subject to considerable wind erosion. Much of the type, however, contains a small amount of organic matter and shows much less tendency to drift. The areas of this type between Clyde and Bellevue include perhaps the loosest and most drifted soil in the county.

The Dunkirk fine sand for the most part occupies rather long, narrow, ridgelike areas near the old beach lines of the former lakes, adjacent to the old rock barriers in the western part of the county, and rounded knolls and dunelike areas in the south and southeastern

part of the county. Some of the areas south of Clyde and between Clyde and Bellevue are quite wide.

The type has a gently rolling to rolling and dunelike surface. Some of the dunes between Clyde and Bellevue are rather steep for farming; but other areas, particularly those in the western part of the county, represent small ridges which rise only a few feet above the surrounding country.

The drainage of this type is good to excessive, but in some places the type is underlain at 3½ to 4 feet by an impervious stratum and the subsoil seems to be very wet, even wetter than that of surrounding heavier types in the spring of the year.

The Dunkirk fine sand is not very highly prized for general farming, but it is quite valuable for fruit production and trucking, and it is extensively devoted to these uses in the vicinity of Clyde. Most of the type is cleared and farmed. In fact, this was one of the first soils farmed by the early settlers, for the reason that it was one of the driest soils at that time. A few scattered areas of the native growth of beech, hickory, oak, and walnut still remain. Where the type is devoted to general agriculture, corn, wheat, oats, and clover are grown. Small areas are sometimes planted to potatoes, especially in the western part of the county. The areas between Fremont, Greenspring, Clyde, Colby, and Bellevue constitute one of the most important fruit-growing sections of the State. Peaches, apples, pears, and cherries are grown. There are several very large cherry orchards on this soil; an orchard between Clyde and Bellevue is said to be the largest cherry orchard in Ohio. Small fruits also are grown, such as strawberries, blackberries, and currants, as well as tomatoes, cabbage, and other vegetables. The location of some commercial nurseries at Clyde has stimulated fruit growing. A large area of the type is devoted to growing cantaloupes and watermelons, which are marketed in Clyde, Fremont, Bellevue, and Tiffin. Melons are also shipped to Toledo and Cleveland. Some cabbage is grown, but this crop is largely confined to the areas of darker sand soils. The type is used to a considerable extent for garden vegetables, especially in the western part of the county where it is hardly extensive enough for the development of commercial fruit and truck growing.

The principal problem in the handling of this soil is to prevent drifting. This is accomplished by keeping the soil covered during the greater part of the year. The growing of small fruits and orchard fruits largely overcomes drifting. Considerable fertilizer is used on this type, but fertilization has not been thoroughly studied and no definite system has been worked out. It is recognized that a well-balanced commercial fertilizer gives good results with general-farm crops. Barnyard manure also produces excellent returns when

applied just before the crop is put in, so that loss from leaching is avoided. Some fertilization is done in connection with fruit growing.

In parts of the county where this type has not been devoted to fruit growing the land is valued at $50 to $75 an acre. In those sections where it has been planted to orchards or small fruits or where the farms have otherwise been generally improved, the valuation is two or three times as large.

One of the best uses that can be made of this soil is general fruit growing, which has been undertaken in the vicinity of Clyde. It is not well suited to general farming, although it is more productive than most sandy soils existing in the form of dunes, as its fineness makes it more retentive of moisture. Where it is devoted to general farming fertilizers should be used. Expensive nitrogenous fertilizers should not be applied, however, since with the aid of liming excellent clover can be grown on the ridges and plowed under to furnish a much cheaper source of nitrogen. The type can well be used for the production of potatoes, which give excellent yields with proper fertilization. The type can also be used for alfalfa when it is limed. There were some excellent fields of alfalfa on this type in the spring of 1917, which had lived through the excessive drought of the fall of 1916; and corn resisted the drought of 1915 practically as well as on some of the heavier and darker-colored types.

Some areas mapped as the Dunkirk fine sand are really composed of patches of Dunkirk and Newton fine sand so intimately associated that it is not possible to indicate them separately on the map. The areas of Dunkirk fine sand, which predominate, are typical, except that in some places the subsoil is wetter and the lower foot of the 3-foot section is streaked with dark iron stains. Included areas of Newton fine sand consist of 7 to 9 inches of black fine sand or loamy fine sand, underlain by bluish-gray, slightly coherent fine sand to a depth of about 12 inches, below which the material is highly mottled and streaked with yellow and with brown iron stains. The total extent of these mixed areas is quite small and they exert little influence on the agriculture of the county. In some cases the patches of Newton fine sand are devoted to cabbage and those of the Dunkirk to grain or orchards, but as a rule the areas of the two types are too small to justify different systems of farming.

Dunkirk fine sand, gravelly phase.—The Dunkirk fine sand, gravelly phase, to a depth of 8 to 10 inches, consists of a light yellowish brown fine sand or very fine sand, underlain by yellow or straw-colored material of almost identical texture but containing occasional lenses of clay and sticky fine sandy loam. Blotches and streaks of rusty-brown color are sometimes observed in the lower subsoil. Gravel occurs over the surface and throughout the soil mass,

although there is no indication of true till in the lower part of the 3-foot section.

This phase occurs mostly in the southeastern part of the county adjacent to the old beach ridges. It is closely associated with the typical Dunkirk and Belmore fine sands, and is really intermediate between them. Its surface is level to undulating, and drainage is sometimes deficient.

The Dunkirk fine sand, gravelly phase, is used to some extent for general farming, but it is regarded as only moderately productive. Corn and wheat, however, give good yields if fertilized, and the soil is recognized as well suited to potatoes and small fruits. It is devoted to some extent to these crops. There are some excellent orchards on this type. In general, there is little agricultural difference between this phase and the typical Dunkirk fine sand. It is possibly more droughty. The principal distinction is in origin, the material giving rise to this phase probably having been deposited in shallow water in approximately its present position, whereas the typical Dunkirk fine sand has been subsequently drifted and assorted by the wind.

The following table gives the results of mechanical analyses of samples of the soil and subsoil of the typical Dunkirk fine sand:

Mechanical analyses of Dunkirk fine sand.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
272210	Soil	2.8	10.9	11.5	42.6	9.1	17.1	5.6
272211	Subsoil	3.8	11.6	12.4	45.4	8.0	14.0	4.9

BELMORE FINE SAND.

The Belmore fine sand, to a depth of 7 to 10 inches, consists of a brown to yellowish-brown fine sand, which has a decidedly less smooth feel than the soil of the Dunkirk fine sand. This is underlain by an incoherent sand to fine sand, of a more reddish brown color. It becomes somewhat coarser and in places slightly gravelly below 24 inches. While a calcareous tendency is rarely encountered within the 3-foot section, the material is usually calcareous within 4 or 5 feet. Throughout the type there occur small patches where calcareous gravelly material occurs within the 3-foot section.

This type is most extensive on the Warren Beach, in the southeastern part of the county. It has a rolling to ridgelike topography, and in general the ridges are slightly more prominent than those occupied by the Belmore loam. Drainage, both surface and internal, is thorough and in some places excessive, owing to the rapid run-off and the open nature of the soil.

The type occupies narrow ridges which are generally traversed by roads. It has been extensively selected for home sites, and is largely devoted to home gardens and orchards. A few areas are devoted to orcharding and melon growing on a commercial scale, and even to general farming. The soil is more productive than the Dunkirk fine sand.

It is probable that most of this type can be used to best advantage for trucking, orcharding, and the growing of melons. Alfalfa also could probably be grown with profit. On the more prominent ridges the soil should probably be limed, in order to assist the sensitive young plants to penetrate to the deeper and calcareous subsurface material.

The following table gives the results of mechanical analyses of samples of the soil, subsoil, and lower subsoil of the Belmore fine sand:

Mechanical analyses of Belmore fine sand.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
272291	Soil	0.4	6.8	10.9	64.2	2.9	10.3	4.6
272292	Subsoil	.5	8.3	11.3	61.8	3.9	11.0	3.3
272293	Lower subsoil	1.2	12.6	14.8	57.5	3.1	7.7	3.2

BELMORE LOAM.

The surface soil of the Belmore loam consists of 7 to 9 inches of brown to dull reddish brown loam, containing a considerable amount of small, rounded gravel. The surface of beaten fields often appears literally covered with these pebbles, which are composed of black shale, igneous material, and some limestone. The subsurface layer is a loam similar to the surface soil but slightly brighter reddish brown in color, owing to the absence of organic matter, and slowly becoming heavier and more sticky with depth. The content of gravel also increases with depth. At 15 to 22 inches the interstitial material is a slightly sticky, reddish-brown, friable clay loam. This rests on rather compact, highly calcareous gravel, which is seen in cuts to be stratified. The deposit of gravel is usually several feet thick.

The areas mapped as Belmore loam are extremely variable in texture. In some places the soil is a fine sandy loam, while in other areas it may be almost a clay loam. It is impossible to indicate all these different textures on the map, and they are included with the dominant type, which is a loam. In some places the clay and gravelly material extends downward throughout the 3-foot section.

There are other places in which the surface material to a depth of 6 to 10 inches contains only a small percentage of gravel, but even here the peculiar gravelly layer is encountered below.

The material is almost invariably highly calcareous in the lower part of the 3-foot section; places where no effervescence is obtained in the 3-foot section represent areas where weathering has been more complete and erosion less active.

The Belmore loam occurs on the long, narrow ridges representing the old beaches of Lakes Maumee, Whittlesey, and Warren, and in smaller areas associated with the old rock barriers in the western part of the county which gave rise to small beach deposits. The largest area of the type mapped is directly south of Clyde. The soil is entirely a beach deposit, representing material deposited by the waves on the old lake shore. The topography is gently rolling to ridgelike. The ridges rise 5 to 25 feet above the surrounding country. They are seldom over 40 rods and usually about 15 rods wide. The drainage and underdrainage of this type are excellent. The reddish-brown color is due to the good drainage, which has continued as weathering has proceeded.

In spite of its high productiveness the Belmore loam is not an important soil agriculturally, owing to its small extent. Much of the type is occupied by roads and farmsteads, which are preferably located on these long, narrow ridges. Practically none of the original growth of sugar maple, ash, and oak remains.

The Belmore loam is devoted largely to growing fruit and vegetables for home use. A considerable acreage is in potatoes, to which crop the soil is well adapted. It is a splendid alfalfa soil, owing to its excellent internal drainage and calcareous subsoil, and it is also used successfully for wheat and corn. In many places, however, it is rather drougthy for the latter crop, owing to a relatively large proportion of gravel. Other areas seem to resist drought quite well, depending almost entirely on the depth of the soil overlying the gravel. It is probable that this soil can be best used for special crops, such as potatoes, fruit, and alfalfa.

The following table gives the results of mechanical analyses of samples of the soil and subsoil of the Belmore loam:

Mechanical analyses of Belmore loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
272227	Soil	5.7	9.6	4.2	24.1	10.4	35.9	10.2
272228	Subsoil	4.7	9.1	3.3	16.4	12.8	33.5	20.4

FOX SILT LOAM.

The Fox silt loam consists of 7 to 10 inches of brown silt loam underlain by slightly reddish brown, gritty clay loam which gradually becomes heavier with depth, showing some stickiness at 22 to 26 inches. Below these depths rounded calcareous gravel is encountered in such abundance that it is difficult to penetrate the material with the soil auger.

The areas of this soil south of Fremont, in sections 8, 17, 20, and 31, are underlain by limestone at depths of 2½ to 3½ feet. The areas northeast of Fremont have a darker surface than is typical of the Fox series, and represent a gradation toward the Waukesha series. The subsoil, however, is typical of the Fox series, except that it is not underlain with gravel within 3 feet.

The areas mapped as Fox silt loam occur on terraces along the Sandusky River. They have been cleared and are used for general farming. The type is recognized as a valuable agricultural soil.

WAUKESHA VERY FINE SANDY LOAM.

The surface soil of the Waukesha very fine sandy loam is a dark-brown to black, smooth, mealy, very fine sandy loam, 8 to 18 inches in thickness. The subsoil is a yellowish-brown, slightly coherent and compact very fine sandy loam to gritty silt loam.

The areas northeast of Ballville and east of Fremont and that southwest of Woodville along the Portage River represent the most typical developments of this soil. The areas south of Ballville along the Sandusky River have a dark-brown to brownish-black silt loam surface soil and a yellowish-brown to brown, light, friable clay loam subsoil, thus representing a gradation toward the Fox silt loam.

The Waukesha very fine sandy loam occurs in small, terrace-like areas along the Sandusky and Portage Rivers. It has a level to undulating surface, and the natural drainage is poor, though easily improved by means of tile drains. The soil is highly productive and well adapted to corn, to which it is largely devoted. Some cabbage and tomatoes are grown.

The following table gives the results of mechanical analyses of samples of the soil, subsoil, and lower subsoil of the Waukesha very fine sandy loam:

Mechanical analyses of Waukesha very fine sandy loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
2722107	Soil	0.0	0.3	0.2	20.8	34.6	34.1	9.7
2722108	Subsoil	.0	.5	.7	19.5	27.8	37.7	13.3
2722109	Lower subsoil	.0	.8	.9	15.2	20.4	46.6	15.9

GENESEE CLAY LOAM.

The Genesee clay loam, to a depth of 8 to 10 or even 12 inches, consists of a black, friable clay loam to silty clay loam. In some places this material may extend throughout the 3-foot section with little change except that the color may become lighter, but the subsurface material is often grayish and shows a trace of mottlings. In such places the subsoil is usually a brownish-yellow to brassy-yellow and gray mottled clay loam. The zonation in this type is on the whole quite indistinct and variable.

The Genesee clay loam occurs in narrow strips along the flood plains of the streams. The areas are seldom over one-fourth mile in width, and in many places their width is only 40 rods or less. This soil is used mainly for pasture. Only a few areas are sufficiently tile drained to permit of farming operations. Corn does very well for a number of years without fertilizer or other treatment. This soil requires considerable care in handling, as it is apt to clod if plowed when too wet.

MUCK.

The surface soil of Muck is dark-brown or black, fibrous peaty material, 8 to 12 and occasionally 14 inches deep. This is usually underlain by a dingy-gray, incoherent sandy loam, which at 12 to 20 inches grades into a soft, plastic, grayish-blue clay. In some places the sandy layer is lacking and in others the clay substratum. In the former the peaty material rests directly upon the clay stratum, and in the latter the subsoil is composed of almost pure sand, locally called quicksand. The areas of clay subsoil are recognized as more productive than those underlain by sand. The subsurface material nearly always contains calcium carbonate in the form of shells or partially disintegrated and weathered shells, and in such cases the immediate surface soil is sometimes slightly calcareous, the subsurface layer of course very highly calcareous, and the lower subsoil moderately calcareous.

The areas mapped as Muck vary widely in composition. In some places the surface soil is slightly sandy. In others the soil is formed partly of clay and the fibrous structure is lacking, in which case it is typical Muck. Again, the subsurface soil and subsoil are a pure sand, with no indication of clay. In still other places the clay is encountered in the lower part of the 3-foot section.

Muck occurs for the most part in widely scattered areas within the lake plain. The largest area is that in Scott Township, west and north of Girton. The surface is everywhere flat or depressed, and drainage is naturally very poor.

This soil is used to some extent for the general farm crops, corn, oats, and wheat. No special crops are grown. Considerable effort is being made by some farmers to drain and improve areas of Muck. The crops grown at present do not yield large returns. In some cases the seed alone is not returned. In other cases fair yields are obtained, such as 35 bushels of corn to the acre, or 20 to 25 bushels of oats, and much better yields are occasionally reported on areas underlain by clay. Fertilizers in different combinations have been tried, including ground limestone, quicklime, and general commercial fertilizers. The profitableness of fertilization has not been definitely ascertained, although some benefit has been observed. The fertilizers used have almost invariably been very low in potash.

The Muck in most cases has been artificially drained to a fair extent, but the drainage systems should be gradually extended. Wherever clay underlies the peaty material it should be worked up into the surface soil or otherwise stirred so that roots can penetrate it. The advisability of using lime in any form is very questionable, indeed, as the material almost invariably is calcareous in either the immediate subsurface layer or the lower subsoil. Small areas that may be slightly acid are exceptional. In using fertilizers preference should be given to those containing potash, as this has almost invariably been found highly beneficial on swamp and peaty lands. However, in areas where the clay subsoil material can be reached with the plow, it is doubtful if it is necessary to use any considerable amount of potash, acid phosphate probably being the main fertilizer ingredient needed. Deep-rooted crops, such as sweet clover, should be grown. It is quite possible that the roots would penetrate to the heavier material which almost invariably underlies the peaty deposits, and would have an effect similar to that of deep plowing. Where other conditions are favorable this land can be used profitably for the production of celery, onions, and similar light truck crops, to which it is devoted on an extensive scale in other parts of the State, as around Kenton, Lodi, and Orrville. Nitrogenous fertilizers should of course not be added to this soil, as it is already very high in nitrogen.

Muck, marly phase.—The Muck, marly phase, to a depth of 8 to 10 inches, consists mainly of dark-brown or black, well-decomposed organic matter. In some cases fibrous material is easily distinguished, while in others the substance is thoroughly decomposed. This black material is underlain by 3 to 6 or 8 inches of white marl, which contains numerous shells in varying degrees of decomposition. Shells also occur scattered over the surface. Below this marly layer there is sometimes a narrow zone of marly sand, which is directly underlain by a drab, plastic clay. Occasionally this sandy material is entirely lacking, while on the other hand the entire lower

subsoil sometimes resembles quicksand. Almost invariably, however, clay material can be found in the lower part of the 3-foot section. The surface material is nearly always calcareous, the immediate subsurface layer is a nearly pure marl, and the subsoil is highly calcareous.

The largest area of this soil occurs in Scott Township, west of Girton. Another area is mapped in the northeastern part of the county. The surface is flat and the natural drainage very poor. It has been much improved by means of ditches and lateral tiles, but in most places these are not extensive enough for best results.

Little timber originally grew on this land, and it was locally called "prairie." The phase is not at the present time an important soil agriculturally. It has been devoted only to general farm crops, and yields have been low. Corn, wheat, and oats, however, have given good results in areas where the immediate subsoil is heavy. No special methods of farming have been followed. The soil is very easily worked and put in good tilth. Almost all the different grades of fertilizer have been used, with widely varying results. Apparently they have all been low in potash. Ground limestone and quicklime have both been applied without appreciable results.

In the improvement of this soil the first problem, after adequate drainage has been provided, is that of proper fertilization. Potassium fertilizers should be given a thorough trial. There is no need of applying lime or nitrogenous fertilizers. The potassium fertilizers should be supplemented by a liberal treatment with acid phosphate. Where possible the heavy clay material should be worked up into the surface mixture of marl and peaty material. Special crops, such as onions and celery, could probably be grown on this soil to good advantage.

MARSH.

In northern Riley Township several large areas bordering Sandusky Bay are marshy throughout the year. The vegetation consists largely of coarse swamp grasses. The soil, as nearly as can be determined, is similar to the Newton silty clay, except that the surface soil is not quite so dark and the subsoil is bluish gray. Some areas of Muck occur in this marsh, but their extent could not be determined.

The areas classed as Marsh in this area have rather remote agricultural possibilities. In order to remove the water from them, diking and pumping would be necessary, requiring a large outlay of capital. Such operations have been carried on successfully in eastern Lucas County and a start is being made in this direction in Sandusky County.

SUMMARY.

Sandusky County, Ohio, is situated in the northern part of the State. It has an area of 413 square miles, or 264,320 acres.

With the exception of a small area in the southeastern part, the county lies within the basin of ancient glacial lakes. These were bordered by three successive ridges, representing the shore deposits, of the receding lakes, Maumee, Whittlesey, and Warren.

The general slope is to the north and northeast. The greater part of the county, within the lake plain, is very level, but there are occasional undulating ridges. The surface in the western part is broken by extrusions of the underlying limestone rock. Some dissection is noticeable along the main drainage channels. The elevation of the county ranges between 580 and 600 feet above sea level.

The county has very poor natural drainage, but this has been in large measure overcome by an extensive system of large open ditches and tile drains.

In 1910 Sandusky County had a population of 35,171,[1] of which about 42 per cent is strictly rural. About 32.1 per cent of the population are foreigners. Fremont, the county seat, had a population of 9,939 in 1910.

Several steam and electric railroad lines afford ready communication with large cities. The wagon roads are fairly good.

The principal types of agriculture in Sandusky County are grain production and live-stock farming. The total value of the grain and hay crops in 1909 was $2,564,521, and the income from all live-stock sources, $1,737,385. Corn is the principal crop, followed by oats and wheat. In several parts of the county orchard and small fruits and truck crops are grown extensively.

There were 2,945 farms in the county in 1910, of which 63.8 per cent were operated by the owners. The percentage of farms operated by tenants is steadily increasing. In 1910 the average size of the farms was 83.9 acres.

The soils of Sandusky County have originated from glacial till derived from limestone and shale; glacial till derived from limestone, sandstone, and shale; beach deposits, lacustrine deposits, and alluvium. Fourteen series of soils are recognized.

The soils derived from glaciated limestone, sandstone, and shale are classed in six series. The most important of those are the Miami, Crosby, Milton, and Randolph.

The Miami soils have good natural drainage and are well adapted for grain production.

The Crosby silty clay loam has poor surface and subsurface drainage. It is not very extensive and is considered a poor soil for agriculture.

[1] According to census of 1920, preliminary count, the population is now 37,109. Fremont, 12,468.

The Milton series includes one type, the silt loam, having a brownish surface soil and a sticky subsoil, with limestone rock within 3 feet of the surface. It is considered a good wheat soil.

The Randolph series also represents very shallow soils, with grayish-yellow to dull-brown surface soils and a dull-brown subsoil. The stony loam is used largely for pasture, but the loam, if properly drained, can be used for general farming. The drainage, however, is difficult to improve.

Soils derived from lacustrine and wind-blown material are classed in the Brookston series. These soils occupy large areas of the lake plain. They have a dark-gray to black surface soil, a yellow-gray to blue-gray subsurface layer, and a yellowish subsoil. This series includes some of the most productive land in the county, and the soils are in a high state of cultivation. They are well adapted to general farming, and some trucking is done on the lighter soils.

The Millsdale stony clay loam includes areas with a black surface soil, and a brownish-yellow clay loam subsoil. Limestone bedrock is encountered at depths of 12 to 24 inches. Some areas are under cultivation, and fair yields are obtained.

The Newton, Lucas, and Warners soils consist of water-deposited material laid down in the old lake plain, and the Dunkirk and Belmore soils of water-deposited material laid down as former beaches.

The Newton series is characterized by a grayish-black surface soil, a yellowish to bluish-gray subsurface layer, and a yellowish subsoil. Seven types are mapped. The lighter members occupy only small areas, while the heavy types include broad stretches of dead level country. The heavier soils are well adapted to corn and general farm crops, while the lighter types are often used for cabbage growing and trucking.

The Lucas series includes lacustrine types having a yellow to yellowish-gray surface soil and a yellowish-brown subsoil. The lower subsoil of the heavier members is distinctly calcareous. Five types are recognized. The lighter soils are often used for growing potatoes and truck crops, while the heavier members are fairly well adapted to fruit growing and general farming.

The Warners loam consists of a dark-gray marly loam, 7 to 9 inches deep, overlying a layer of marl which rests on calcareous, heavy clay. It is cleared and farmed and gives good yields of general farm crops.

The Dunkirk series includes soils that are yellow throughout the 3-foot section. The material is typically wind blown. Only the fine sand with a gravelly phase is recognized. These are good agricultural soils, especially valuable for truck and fruit growing. The gravelly phase is often used for growing potatoes and small fruit.

The Belmore series includes types with a brown surface soil and a reddish-brown subsoil overlying calcareous gravel. Two types—the loam and fine sand—are recognized.

The soils occupying glacial terraces or outwash plains are classed in two series, the Fox and Waukesha. The Fox silt loam has a yellowish-brown surface soil and a brown subsoil overlying rounded gravel. It is used for general farming. The Waukesha very fine sandy loam has a brownish-black to black surface soil and a yellowish-brown subsoil. It is used mostly for growing corn, but some cabbage and tomatoes are grown.

The Genesee clay loam occupies the first bottoms or flood plains along streams. It is used mainly for pasture, as only a few areas have been tiled sufficiently to permit of farming operations.

Muck includes areas of soils formed from decomposing plant remains, mixed with some mineral matter. These areas are farmed to some extent.

Wet areas supporting a growth of swamp grasses and requiring extensive pumping and diking before they can be farmed are mapped as Marsh.

○

ORTON LIB

[PUBLIC RESOLUTION—No. 9.]

JOINT RESOLUTION Amending public resolution numbered eight, Fifty-sixth Congress, second session, approved February twenty-third, nineteen hundred and one, "providing for the printing annually of the report on field operations of the Division of Soils, Department of Agriculture."

Resolved by the Senate and House of Representatives of the United States of America in Congress assembled, That public resolution numbered eight, Fifty-sixth Congress, second session, approved February twenty-third, nineteen hundred and one, be amended by striking out all after the resolving clause and inserting in lieu thereof the following:

That there shall be printed ten thousand five hundred copies of the report on field operations of the Division of Soils, Department of Agriculture, of which one thousand five hundred copies shall be for the use of the Senate, three thousand copies for the use of the House of Representatives, and six thousand copies for the use of the Department of Agriculture: *Provided*, That in addition to the number of copies above provided for there shall be printed, as soon as the manuscript can be prepared, with the necessary maps and illustrations to accompany it, a report on each area surveyed, in the form of advance sheets, bound in paper covers, of which five hundred copies shall be for the use of each Senator from the State, two thousand copies for the use of each Representative for the congressional district or districts in which the survey is made, and one thousand copies for the use of the Department of Agriculture.

Approved March 14, 1904.

[On July 1, 1901, the Division of Soils was reorganized as the Bureau of Soils.]

Areas surveyed in Ohio.

U.S. DEPT. OF AGRICULTURE
BUREAU OF SOILS
MILTON WHITNEY, CHIEF
CURTIS F. MARBUT, IN CHARGE SOIL SURVEY

SOIL MAP
OHIO
SANDUSKY COUNTY SHEET

OHIO AGRICULTURAL EXPERIMENT STATION
CHARLES E. THORNE, DIRECTOR
E. R. ALLEN, IN CHARGE SOIL SURVEY

CONVENTIONAL SIGNS

CULTURE
(Printed in black)

City or Village, Roads, Buildings, Wharves, Settlements, Breakwater, Levee, Lighthouse, Fort.

Boundary roads and Trails

Railroads, Steam and Electric

Bridges, Ferry

R.R. crossings, Tunnel

Ford, Dam

School or Church, Cemeteries

Mine or Quarry, Mine dumps, Made land.

Bluff, Escarpment, Rock outcrop and Triangulation station

Stony and Gravelly areas

Soil boundaries

Boundary lines

Boundary lines

Boundary lines

U.S. township and section lines

RELIEF
(Printed in brown or black)

Contours, Depression contours

Prominent Hills, Mountain Peaks

Sand, Wash, and Sand dunes

Shore and Low-water line, Sandbar

DRAINAGE
(Printed in blue)

Streams

Lakes, Ponds, Submerged lake

Intermittent streams

Springs, Canals and Ditches, Flumes

Salt marsh

Submerged marsh, Mud flats

The above signs do not appear on the soil maps. Variations from the usage appear in some margin of earlier dates.

LEGEND

Miami fine sandy loam (Mf)	Milledale stony clay loam (Mc)	Lucas fine sand (L)
Heavy-subsoil phase (Mf)	Dunkirk fine sand (D)	Lucas gravelly fine sandy loam (Lf)
Miami loam (M)	Gravelly phase (D)	Lucas very fine sandy loam (Lv)
Miami clay loam (Mc)	Belmore fine sand (Bf)	Coarse phase (Lc)
Light phase (Mc)	Belmore loam (Bm)	Lucas silt loam (Ls)
Miami clay (Mt)	Genesee clay loam (G)	Lucas silty clay loam (Lc)
Crosby silty clay loam (Cs)	Newton sandy loam (N)	Fox silt loam (F)
Milton silt loam (Ms)	Newton fine sandy loam (Nf)	Waukesha very fine sandy loam (W)
Randolph stony loam (Rs)	Newton very fine sandy loam (Nv)	Warners loam (Wl)
Randolph loam (Rl)	Newton loam (Nl)	Marsh (Mh)
Brookston loam (Bl)	Gravelly-subsoil phase (Nl)	Muck (Mu)
Brookston clay loam (Bc)	Newton silt loam (Ns)	Marly phase (Mu)
Brookston silty clay loam (Bs)	Newton clay loam (Nc)	
Brookston clay (B)	Newton silty clay (Ny)	

BASE MAP FROM
U.S. GEOLOGICAL SURVEY SHEETS

Scale 1:125,000
3 0 3 Miles
5 0 5 Kilometers

Contour interval 10 feet.
Datum is mean sea level.

W.E. McLendon, Inspector, Northern Division
Soils surveyed by E.R. Allen, in charge,
Guy Correy, W.G. Boardman, Oliver Bossard,
and G.K. Sivasliian of the Ohio Agricultural
Experiment Station, and Charles N. Mooney
of the U.S. Department of Agriculture.

LITHO. & PRINTED BY U.S. BUREAU OF SOILS

Field Operations
Bureau of Soils
1917